MINING engineering

JANUARY 1958

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Coming Events

Jan. 8, AIME San Francisco Section, speaker: W. T. Griswold; subject: *Pima*; Engineers' Club, San Francisco.

Jan. 10, AIME St. Louis Section, joint meeting with AIChE St. Louis section; speaker: N. E. Berry; subject: *New Developments in Uranium Processing;* Hotel York, St. Louis.

Jan. 13, AIME Minnesota Section, annual meeting, Hotel Duluth, Duluth.

Jan. 14, 15, 19th Annual Mining Engineering Symposium, sponsored by University of Minnesota, in conjunction with AIME Minnesota Section, Hotel Duluth, Duluth.

Jan. 16, AIME Utah Section, panel discussion: *Industrial Engineering Practices in the Mineral Industries;* moderator—I. K. Hearn; Salt Lake City.

Feb. 12, AIME San Francisco Section, speaker: Robert Koenig, Cerro de Pasco Corp.; subject: *Peru: Its Geology and Mining;* Engineers' Club, San Francisco.

Feb. 16-20, AIME Annual Meeting, Hotels Statler and Sheraton-McAlpin, New York.

Mar. 27-29, AIME Pacific Southwest Mineral Industry Conference, St. Francis Hotel, San Francisco.

Apr. 9, AIME San Francisco Section, speaker: Ed Hassan; subject: *Kaiser Aluminum;* Engineers' Club, San Francisco.

Apr. 17-19, AIME Pacific Northwest Regional Conference, Spokane.

Apr. 25, AIME Pennsylvania-Anthracite Section, spring technical meeting, Hazelton, Pa.

May 5-6, AIME North Texas Section, Third Biennial Secondary Recovery Symposium, Wichita Falls, Texas.

May 9-11, AIME Uranium Section, Third Annual Uranium Symposium, Moab, Utah.

May 24, AIME Colorado MBD Subsection, Broadmoor Hotel, Colorado Springs, Colo.

June 26, AIME Pennsylvania-Anthracite Section, summer meeting, Split Rock Lodge, White Haven, Pa.

Sept. 10-12, AIME Rocky Mountain Minerals Conference, Newhouse Hotel, Salt Lake City.

Oct. 23-25, AIME Mid-America Minerals Conference, St. Louis.

Oct. 25-Nov. 1, Society of Exploration Geophysicists, annual meeting, Roosevelt Hotel, New Orleans.

MINING engineering

VOL. 10 NO. 1 JANUARY 1958

COVER

Use of large pieces of equipment, such as the dragline chosen by artist Herb McClure for this month's cover, is one way of avoiding the profit squeeze. Another is an intelligent approach to income tax problems in relation to development and exploration, as outlined in the article on page 91.

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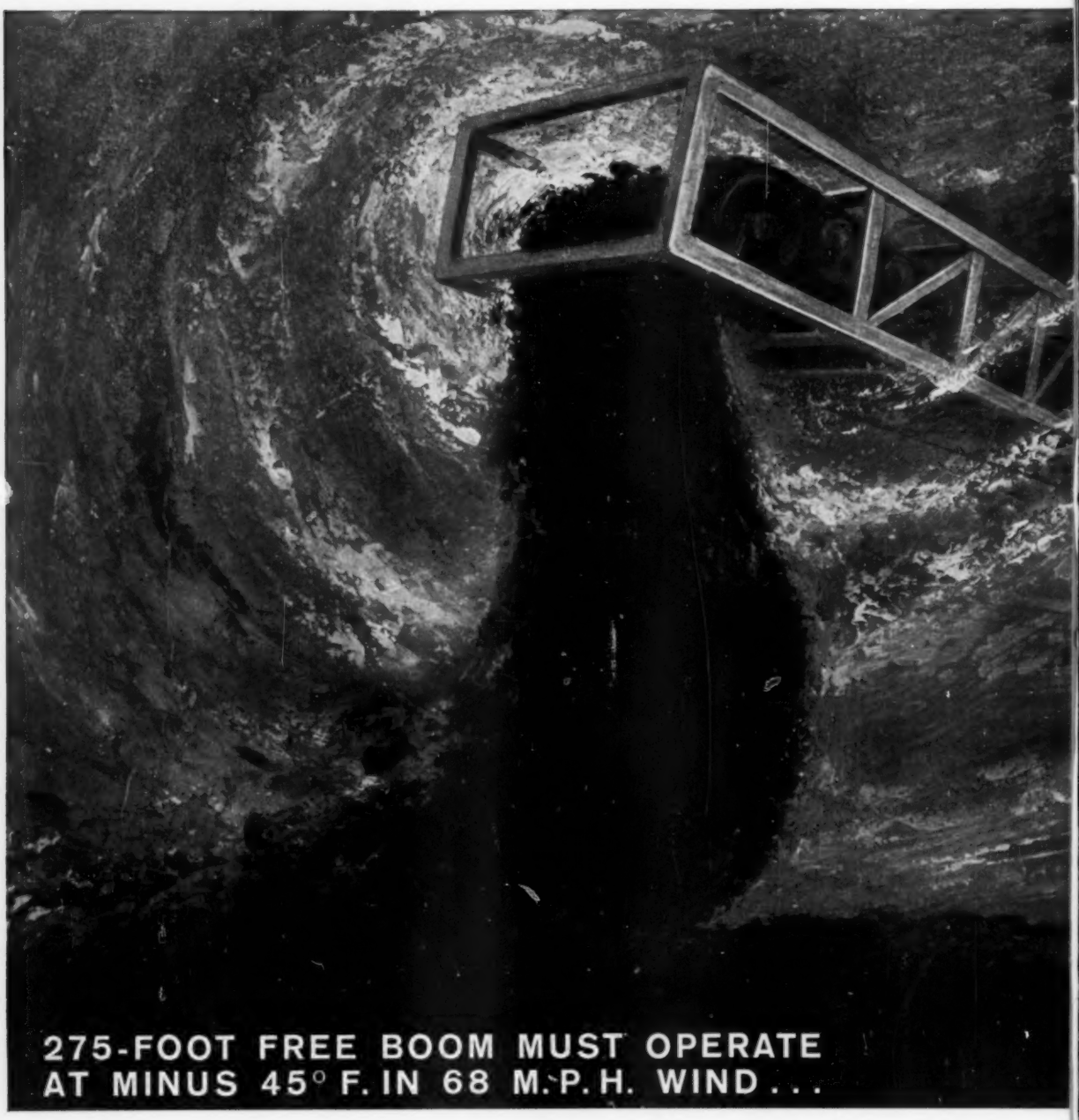

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What does this nickel-containing steel have that justifies such confidence?

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— MEN AVAILABLE —

Sales Engineering or Field Sales, B.S. in mining engineering, age 34, 5½ years industrial loss prevention engineering in varied industries. Conducted plant inspections, made recommendations, wrote reports, and sold intangible ideas and recommendations to top plant management in six northeastern states and Canada. Prefer East, Northeast, or Southeast. M-377.

Project Engineer, 28, B.S.C.E., Junior Member of AIME, registered; seven years varied engineering and production experience in mining and chemical industries. Want responsible plant engineering or administrative position. Cost conscious. Can supervise men. Will travel half time. Some Spanish. Prefer western U. S. or foreign location. M-378.

Manager or Assistant Manager, graduate mining engineer, age 47. Recently manager of foreign mining operation. Experienced in mining, ore beneficiation, administration, costing, purchasing, and handling of personnel. Knowledge of Spanish. M-379.

Exploration or Junior Mine Engineer—Mineral, 27, B.S. in mining. Two years experience junior mine engineer; survey and computation, develop planning in copper, contract measurement, etc., in lead and zinc. Strong interest in geology with San Francisco headquarters. Presently located in Montana. A-613.

Superintendent, Foreman, Engineer, open pit or underground mine, 38, E.M. Eleven years experience general superintendent, shift boss, engineer in tungsten, gold, manganese, iron—open pit and underground. Production safety, locate, map, explore, equipment maintenance, contract pay, ventilate. Prefer U. S. Reside in California. A-648.

Mining Engineer, 27, single, B.S. and bachelor degrees in mining engineering; B.S. in engineering administration. Two years military experience; two and one half years open pit iron ore experience as mining engineer and mine engineer. Experience includes planning, layout, estimating, and scheduling of ore, stripping, and exploration operations. Available immediately, foreign or domestic. Desire responsible position with advancement opportunities. M-380.

Manager, General Superintendent, mine or mill, 34, mining engineer. Eight years experience mining and milling including general superintendent of 100-tpd manganese operation using magnetic-gravity separation. Open pit, underground experience in manganese, gold, antimony, and mercury. Two years metallurgical research laboratory development; knowledge carbonate flotation techniques. Have commercial pilot's license. Desire western United States. Reside in California. A-663.

— POSITIONS OPEN —

Mining Engineer, experienced in uranium exploration and the mining of uranium. Salary, open. Location, Montana. W5615.

Mine Master Mechanic, 45 to 50, with broad practical and supervisory experience in maintaining equipment in fully mechanized underground mines. Salary commensurate with ability. Submit complete work record and references. Location, West. W5603.

Research Engineer, mineral dressing, applied research on nonmetallics. B.S. in mineral dressing or B.S. in related field with beneficiation experience. Practical approach and broad range of interests necessary. Salary dependent on qualifications. Location, Southeast. W5601.

Mining Engineer, for open pit mine. Must be graduate with degree in mining engineering. One to three years experience desired. Location, Southeast. W5591.

Mine Shift Boss, young, with mining engineering training and underground experience. Single status. Some knowledge of Spanish. Salary, $4800 to $5100 a year plus bonus, room, and board. Location, Central America. F5581.

Mining Engineer, graduate, with five to ten years experience, to take charge of running an open-pit mining operation for barite. Will report directly to superintendent. Salary, $7800 a year plus living allowance. Location, South America. F5577.

Sales Engineer, young, with engineering training and some mining experience, for sales and service work covering rock drills. Salary, $6000 a year plus bonus. Location, New York. W5417.

Assistant Manager, mining or metallurgical engineering graduate, with at least 15 years metal mining and milling experience. Salary, about $10,000 a year. Location, East. W5353.

Mining Superintendent, for U. S. company operating 1000-tpd open pit mine. Technical education desirable. Married accommodations available in small community. Salary, open. Apply by letter giving complete information. Location, northern South America. F5395.

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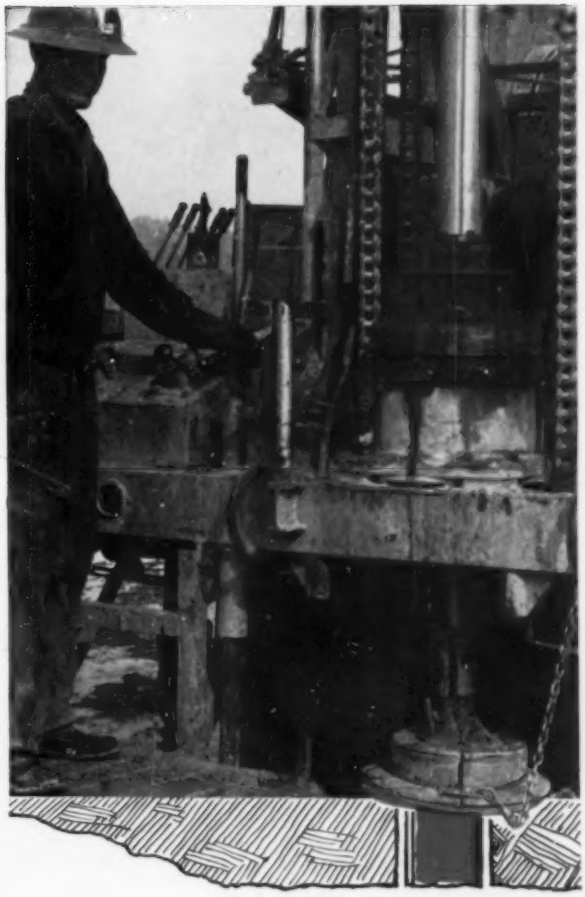

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LETTERS

Editor
Mining Engineering
Dear Sir:

The phrase "world's most extensive uranium deposit" seems somewhat misleading when applied to the South African potential reserves of 1.1 billion tons reported in your November issue.

A truer measure for *world's most* honors would seem to be economically recoverable quantity of uranium oxide. South African reserves at 0.47 lb per ton contain 517 million lb. American reserves recently estimated at 67 million tons grading 5.4 lb per ton contain 362 million lb. Reserves in the Blind River field of Canada, with which I have been associated, are alone recently estimated (G.S.C. Paper 56-7) at 320 million tons grading 2.38 lb per ton, and contain 762 million lb of U_3O_8.

Yours very truly,
Franc R. Joubin

Sputnik Again!

To: The Editor:

Since the advent of Sputnik, the Translation Dept. of the Engineering Societies Library has noted a substantial increase in inquiries from American engineers and firms interested in translations of Russian technical publications. Today more and more translations of Russian technical and scientific material are becoming available, particularly some of the more recent publications. The Engineering Societies Library directs inquiries to the appropriate man or organization from whom existing translations are obtainable. When no existing translation of a particular technical item is known, the Engineering Societies Library will, on order, translate it correctly into good English. Translations are made from Russian or any other foreign language.

Also, there is an increasing demand for more up-to-date abstracting and indexing of original Russian technical and engineering information not necessarily translated as yet. The Engineering Index Service, which indexes the engineering publications received at the Engineering Societies Library, is expanding its coverage of Russian publications. In contrast to the period immediately following World War II, the Russians are making their technical publications much more readily available. They have expressed great interest to the Engineering Societies Library in enlarging existing exchange arrangements, whereby the Engineering Societies Library sends them the publication of its Four Founder Societies for equivalent Russian material. This exchange is of great benefit to America, and will be further developed.

Ralph H. Phelps
Director, Engineering
Societies Library

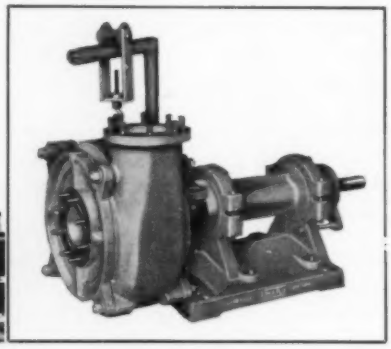
BOOKS

Second Annual **Symposium on Mining Research,** Bulletin No. 94, *Missouri School of Mines,* University of Missouri, Rolla, Mo., 150 pp., 1957.—This bulletin presents the proceedings of the Second Annual Symposium on Mining Research sponsored jointly by the Missouri School of Mines and Metallurgy and the U. S. Bureau of Mines for the purpose of benefiting industry, research agencies, and educational institutions. The information presented is a record of some of the significant and continuing achievements being accomplished in the mining industry today. Among papers included are: application of tunnel mining in hard rock, rotary drilling equipment, mining research, rock breakage, and principles of blasting. The bulletin is replete with photographs, tables, charts, diagrams, and maps.

The Industrial pH Handbook, compiled and edited by Thomas J. Kehoe,

(Continued on page 126)

A truckload of economy for a base metals concentrator in Northern Quebec...



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10 all-new Extra Heavy Duty Series

GVW's up to 51,000 lb. For '58, ten new basic series are added to Ford's already extensive Heavy and Extra Heavy Duty line. Four new Tilt Cabs, four new Conventionals, and two new Tandem models offer GVW ratings up to 51,000 lb.

GCW's up to 75,000 lb. New T-950 Tandem is rated for 75,000-lb. GCW. Biggest single-rear-axle models are rated for 65,000-lb. GCW.

Front axle capacities up to 15,000 lb. Choice of three front axles in most new Ford Extra Heavies. Rated capacities of 9,000 lb., 11,000 lb. and 15,000 lb.

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Bogie axle capacities up to 38,000 lb. For '58 there are two new Extra Heavy Duty Tandem Axle models. The new T-950 Series features a tandem rear axle assembly rated for 38,000 lb. New T-850 Series offers choice of 28,000- or 34,000-lb. bogies.

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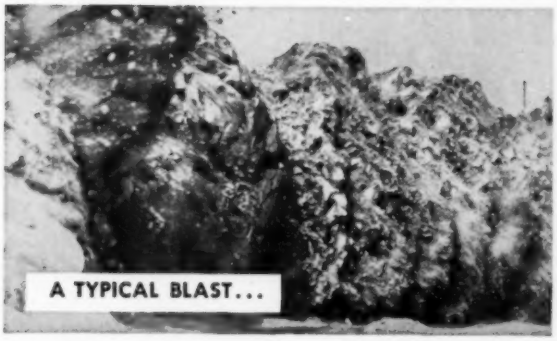

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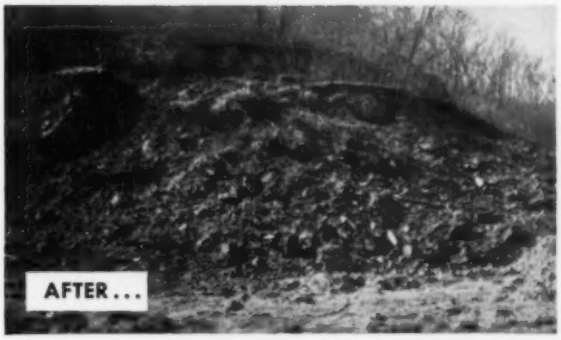

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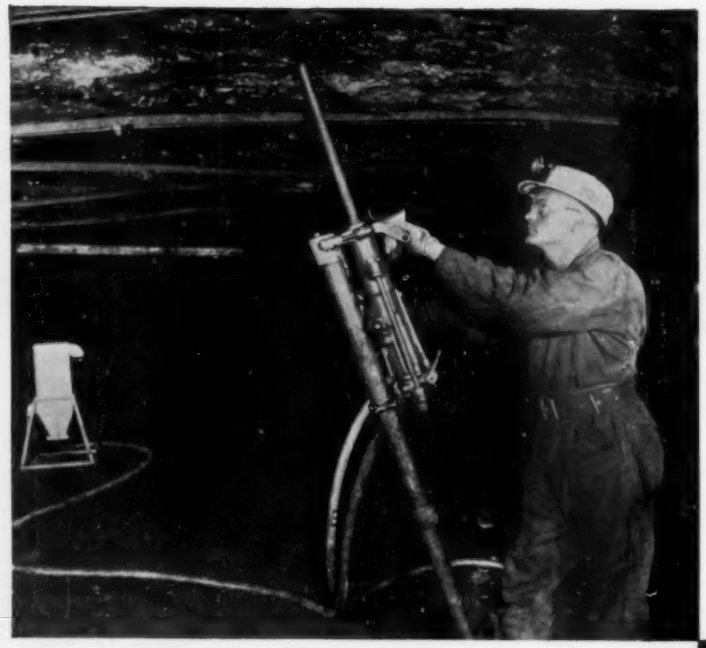

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Quieter Operation — no unnecessary ear-splitting whine or howl in dust collection.

Highest Drilling Speed — because stronger vacuum and larger dust ports assure non-clogging operation.

Lower Bit, Rod and Shop Costs — tapered bit and rod connections eliminate need for furnaces, threading and forging equipment.

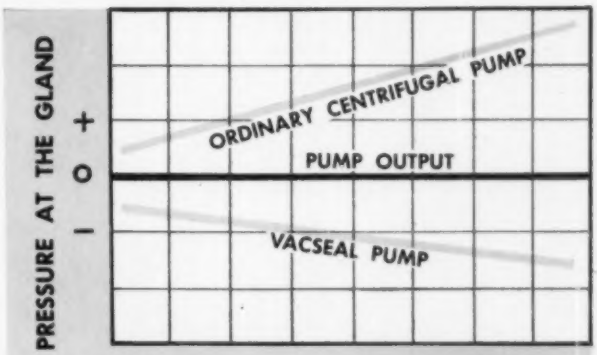
For the complete story on this revolutionary new VACUJET stoper, call your I-R man or send today for Bulletin No. 4195.

COMPRESSORS • CARSETS BITS • ALLOY RODS • HYDRA-BOOM JUMBOS
HOSE • JACKDRILLS • IMPACTOOLS

VACSEAL PUMP

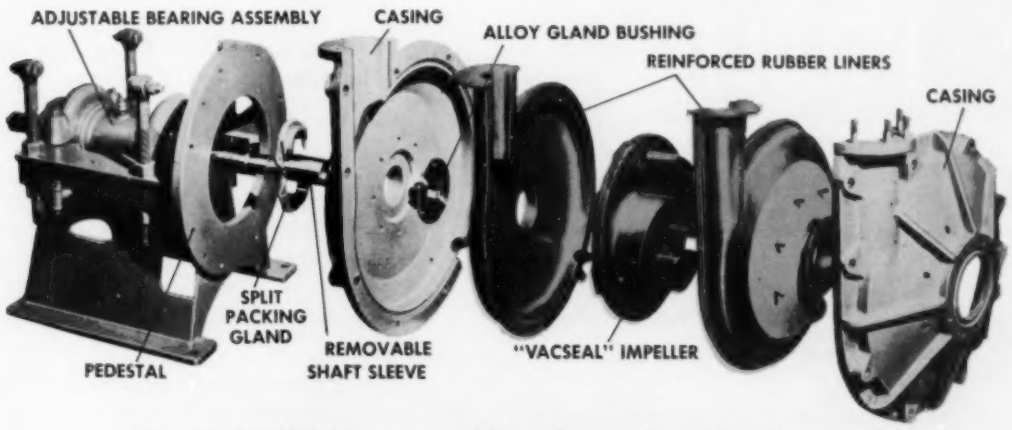
"The harder it pumps the better it seals"

VACSEAL supremacy rests on the *original* VACSEAL impeller design that eliminates leakage at the pump gland. The harder it works the tighter it seals—while the conventional centrifugal pump shows pressure build-up at the gland with increase of speed. Because of this advanced pump design, materials being pumped do not come in contact with the packing or the shaft sleeve. Result – no leakage and greatly reduced shaft wear! The rugged VACSEAL handles all types of material, including: abrasive pulps, acid and corrosive solutions, tailings, semi-solids and many other difficult to handle materials.



When VACSEAL PUMP is operating the pressure on the gland is less than atmospheric pressure.

VACSEAL PUMPS are available in many models, including: fixed or replaceable, metal reinforced, rubber linings and all alloy types and in sizes ranging from 1½" to 8". Write for additional data and performance records on these pumps. No obligation.



4" x 6" VACSEAL pump with replaceable rubber liners.

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VP-517

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GALIGHER PRODUCTS: AGITAIR® Flotation Machine, VACSEAL Pump, Geary-Jennings Sampler, Acid-proof Sump Pump, Geary Reagent Feeder, Laboratory AGITAIR® Flotation Machine, Laboratory Pressure Filter, Laboratory Ball Mill, Rubber Lined and Covered Products, Plastic Fabrication.

BACKGROUND:

In 14 years of strip mining, the Dulin Bauxite Company, Inc., contracted for dirt removal. The company studied contractors' production records, types of equipment used.

RESULT:

Last year, when the Dulin firm bought its own equipment, it selected Caterpillar-built machines exclusively.

The picture above shows how the firm is using the equipment at its bauxite strip mining operation near Little Rock, Ark. In this pit some 300,000 yd. of overburden are being removed at the rate of 4,200 yd. per day by 3 CAT* DW21 Tractors with No. 470 LOWBOWL Scrapers, push-loaded by a mighty D9 Tractor.

Here is the result of experience in action—and doing fine! Says L. D. Riffe, vice-president of the firm: "We find that this method of moving dirt is the best from the standpoint of high production and economy."

There are plenty of good reasons why these rigs are the best method to move dirt. The DW21-No. 470 combination has the capacity for big-volume hauling—18 cu. yd. struck, 25 cu. yd. heaped. But more important than capacity, the No. 470's LOWBOWL design has greater loading efficiency than any other make of scraper in its class. Actual tests show that the No. 470 gets its rated capacity load and is on its way while other scrapers are still in the cut, struggling for the last few yards. And when it has its big load, the 300 HP (maximum output) DW21 moves it at high speeds, efficiently.

Let your Caterpillar Dealer show you how these rugged rigs can move material faster and cut costs in your operation. You can depend on him for sound advice now—for fast service and parts you can trust after you buy.

Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

CATERPILLAR*

*Caterpillar and Cat are Registered Trademarks of Caterpillar Tractor Co.

WANTED—
THE HARD WORK

Manufacturers News

News
Equipment
Catalogs

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Prevent Stockpile Erosion

Mining Chemicals Dept., *American Cyanamid Co.*, offers a new product for forming protective crusts over mineral and coal fines either in stockpiles or open rail cars. Diluted with water and sprayed on the surface of the coal or ore, it forms a tough crust which prevents wind and rain erosion. American Cyanamid offers samples of film-forming Reagent S-3152 and technical notes on its use. **Circle No. 1.**

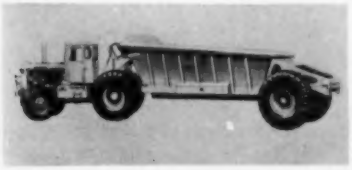
Front End Loader

Euclid Div. of General Motors Corp. has available the smallest of a new line of front end loaders. Rated payload capacity of the Model

L-7 is 19 cu ft heaped, max 3000 lb. Featured is nonstop high-low power shift transmission. Speeds range to 11 mph forward or reverse. Equipped with front wheel drive powered by a 49-hp gasoline engine, unit has rear-wheel steering. Overall length with bucket down is just over 10 ft. Overall height with operator is about 6 ft 10 in. **Circle No. 2.**

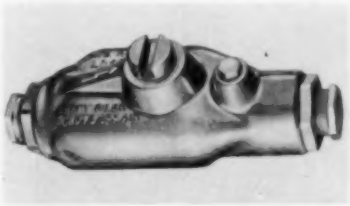
Bottom Dump Trailer

Athey Products Corp. has announced a new 40-ton capacity bottom dump trailer incorporating several design advances. Capacity—80,000 lb—is almost four times trailer weight, a feature made possible through use of high-strength T-1 steel in body construction. In addition, a third (rear) door opens simultaneously with the bottom doors and permits smooth flow-out of material. Together with 5-ft rear clearance, this design eliminates hang-up and need for pusher units at dump or fill. Matched to the Caterpillar DW20 tractor, the trailer, designated PW20, has speeds up to 32.1 mph and can make 90° turns in 38 ft 4 in. **Circle No. 3.**



Automatic Line Oiler

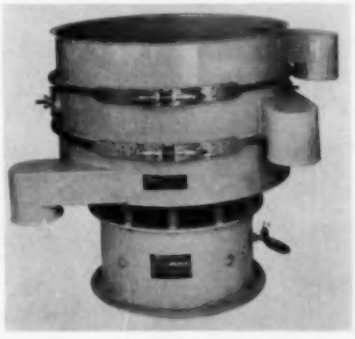
Le Roi Div., Westinghouse Air Brake Co., offers a line oiler which shuts off the air supply of pneumatic tools when its oil is used up. One-pint capacity is more than adequate



for a single shift, but oiler can be refilled while in operation. Streamlined aluminum body weighs only 9 lb, making it easy to move air lines. Top capacity is 300 cfm. **Circle No. 4.**

Vibrating Screen Separators

Three new 30-in. diam vibrating screen separators in 1, 2, and 3-deck models by *Southwestern Engineering Co.* round out the Sweco line of 18 and 48-in. diam units. The new 30-in. models operate on the same



3-dimensional principle and provide high efficiency and high output rate. Carbon steel or type 316 stainless steel construction is available. **Circle No. 5.**

Rock Dust Distributor

Especially adapted to continuous mining, the Bantam 400 rock dust distributor by *Mine Safety Appliances Co.* permits quick application of dust up to the face and into return airways. Self-propelled unit travels at a tram speed of 1½ mph and can discharge dust through 400 ft of 2-in. hose at rate of 30 lb per min. Minimum height is 27 in. with 80-lb capacity dust hoppers, 31 in. with 160-lb capacity hoppers. **Circle No. 6.**

VIP

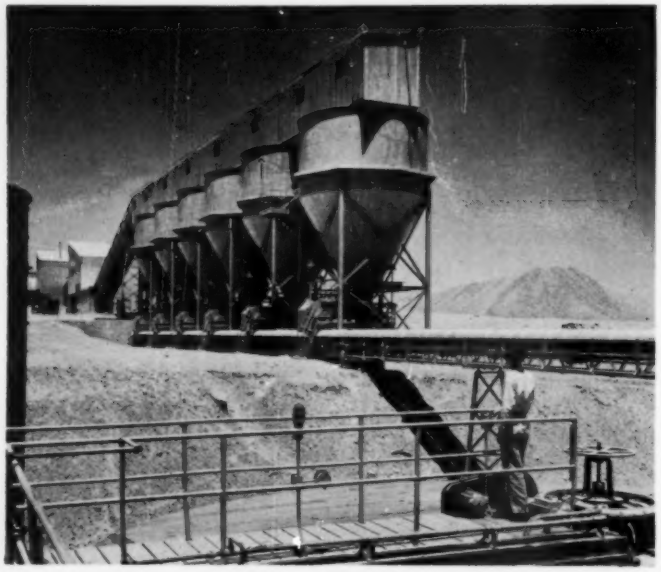
A low-cost, portable seismic data processing system is offered by *Texas Instruments Inc.* Designated VIP (variable intensity plotter), it displays corrected seismic data on a 20-in. cathode ray tube for easy examination, and on a 5-in. tube for photographic recording. Output of 24 recording channels may be processed simultaneously. Plotter is arranged so that the horizontal and vertical axes of the tubes correspond to seismometer spread and depth, respectively. Two sections, visual display unit and computing unit, together weigh 150 lb. **Circle No. 7.**

Test Sieve Shaker

A new vibrating test sieve shaker by *Syntron Co.* features improved electromagnetic drive, which gives faster gradation and rheostat-voltmeter, which permits constant 90-v operation for accurate comparison tests. Shaker has reset timer and spirit level, holds six standard 8-in. sieves and bottom pan. **Circle No. 8.**

Carbide Surfacing

Hexagonal plates of hard cemented carbide mounted on a flexible adhesive backing ready for bonding to metallic surfaces may be used in such applications as ball mill linings and wear plates for mills says *Kennametal Inc.* The material, Kenplate, can be bonded by epoxy adhesives, silver solder, or brazing materials. Three thicknesses are available. **Circle No. 9.**



Blending . . .

Ore blending is particularly important in some uranium concentration. Multiple storage and conveying designed and built by Stearns-Roger has met the requirements of this southwestern producer. For materials handling, as for other important operations in the processing of metallic or non-metallic ores, rely on the complete services of Stearns-Roger for design, engineering, fabrication or field erection.

Stearns-Roger
THE STEARNS-ROGER MFG. CO. • DENVER, COLORADO

DENVER • HOUSTON • EL PASO • SALT LAKE CITY
Stearns-Roger Engineering Company, Ltd., Calgary, Alberta

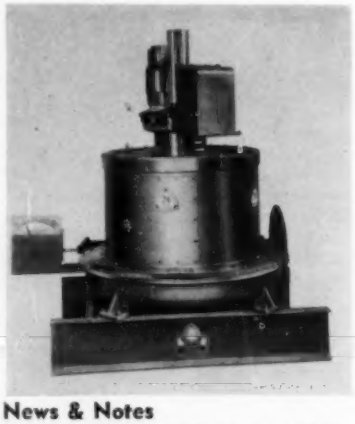
There is no substitute for experience . . .

Mining Tractor

New 55-hp TD-6 crawler tractor by *International Harvester Co.* features 5-ft profile and a new scrubber that cools exhaust gases to max 160°F. Overall width with Drott Four-in-One bucket is 68 in. Length is 160 in. **Circle No. 10.**

Automatic Thickener

A raising and lowering thickener mechanism in a new unit by *Denver Eqpt. Co.* allows the operator to take advantage of improved flocculating agents for faster settling. When overload occurs, rakes are raised automatically in increments until they are out of the overload. When overload is relieved, rakes gradually return to normal position. Unit is now available in the 16 to 20-ft standard duty thickeners. **Circle No. 11.**



News & Notes

Two new metallurgical laboratories have been opened by *Gardner-Denver Co.*, manufacturer of pumps, rock drills, compressors, and air tools. One will serve headquarter plants at Quincy, Ill., the other, plants of the Keller Tool Div. in Grand Haven, Mich. . . . *International Harvester Co.* has arranged to purchase for resale back hoes and heavy-duty front-end loaders from Cone Automatic Machine Co. of Windsor, Vt., and Wagner Iron Works of Milwaukee. International Harvester will distribute their products under the names IH Pippin and IH Wagner . . . *Hewitt-Robins Inc.* reports a speed record has been set by a 2-mile conveyor system which it designed and manufactured. Moving gravel at Little Valley, Utah, the system averaged 83,333 tpd during a recent 30-day period. Belts speed along at 850 fpm, about double the usual pace.

(21) ROD DECK SCREEN: For high capacity separations of dry, wet, sticky, or gummy ores and minerals *Nordberg Mfg. Co.* offers five new larger size models of the Symons rod deck screen. A new bulletin describes ten screen sizes, ranging from 3 to 6 ft in width and 6 to 10 ft in length. Screen surface may quickly be repaired when necessary by simple replacement of its spring steel rods.

(22) COMPANY MAGAZINE: "Carburized steel for better drill rods" is a feature article in the first issue of *Mining Clipboard*, a new publication of *Gardner-Denver Co.* Booklet, which will be mailed bi-monthly, is designed to provide timely equipment tips.

(23) BORALLOY: New boralloy sprockets on Cat D8 and D9 tractors are said to wear up to twice as long as conventional types. *Caterpillar Tractor Co.* supplies details in a new 8-page booklet.

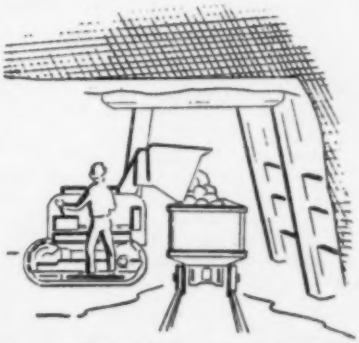
(24) ALUMINIZED CLOTHING: "Hot spot" job assignments lose their hazards when workers are outfitted in the new line of M-S-A aluminized asbestos safety clothing listed in *Mine Safety Appliances Co's.* 4-page, illustrated Bulletin 1301-7.

(25) HANDBOOK: "The Handbook of Rules Governing the Operation of Mines," revised to incorporate amendments to The (Canadian) Mining Act approved at this year's session of the Legislature, is now ready for distribution by the *Ontario Department of Mines.* Handbook covers Part VIII of the Act and certain applicable sections of Part X.

(26) V-BELT DRIVES: A 108-page manual on selection and operation of Dodge V-belt drives is available from *Dodge Mfg. Corp.* Sections cover standard, variable speed and special drives, Taper-Lock sheaves, Sealed-Life V-belts, and bushings and hubs.

Free Literature

(27) TRACKLESS MINING: *Joy Mfg. Co.'s* new shovel loader, tractor, and bulldozer are described in new folders. Basic tractor is adaptable to muck handling, drilling, excavating, bulldozing, material handling, and other jobs in trackless mining systems. Units are available either air or electric powered.



(28) EARTHMOVING MACHINES: The DW15 (Series E) Tractor and No. 428 Lowbowl Scraper are featured in a new brochure offered by *Caterpillar Tractor Co.* The Lowbowl scraper is matched in size to the weight and horse power of the DW15 tractor. Scraper also features faster loading and bigger loads. Both units have wide section, low pressure tires for extra traction and flotation. Folder includes photographs and charts of the new models.

(29) MINE VENTILATION: A new 24-page catalog from *American Brattice Cloth Corp.* describes production, construction, and application of ABC flexible ventilation tubing, brattice cloth, and powder bags. Shown are typical installations in both metallic and non-metallic mines.

(30) ROTARY KILN: *Vulcan Iron Works* claims development of a new rotary kiln that will simplify foundation plans, avoid frictional wear, reduce torque and power load, and save maintenance cost. A new brochure supplies details.

(31) BELT CONVEYOR SCALES: ABC's Scale Div., *McDowell Co. Inc.* has a redesigned line of belt conveyor scales for weighing, controlling, and totalizing free-flowing bulk materials. Scales are built to an accuracy of ½ to 1 pct of flow over their entire weight range and may be used to control, blend, and proportion materials flow.

(32) SPECTROGRAPHS: The third in a series of spectrochemical analysis guidebooks, published by England's Hilger & Watts Ltd., is now being distributed by *Jarrell-Ash Co.* The 24-page catalog CH403 describes a variety of prism and grating instruments, and related accessories. Featured is data on design, application, and characteristics of each type of instrument. Specification tables and graphs permit quick comparison of individual performance ranges.

(33) CORE BARRELS: A simple 8-page guide describing the various barrels used by core drillers has been published by the *E. J. Longyear Co.* Pamphlet includes information on seven types and depicts with diagrams and illustrations single tube, double tube, swivel type, and wire line core barrels. Conditions for which one type or another is recommended are also described.

(34) SAMPLERS: Wet and dry sampling units are detailed in *Denver Eqpt. Co.* Bulletin S1-B4. The 12-page brochure contains a typical sampling flowsheet and tips on designing a sampling plant, as well as specific data on such units as Vezin type, Snyder type, visual, and laboratory samplers. Denver sample processing equipment is also covered.

MAIL THIS CARD

for more information on items described in Manufacturers News and for bulletins and catalogs listed in the Free Literature section.

1

Mining Engineering **29 West 39th St.** **New York 18, N. Y.**

Not good after Apr. 15, 1958—if mailed in U. S. or Canada

Please send { More Information ☐ / Price Data ☐ / Free Literature ☐ } on items circled.

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51	52	53	54	55	56	57	58	59	60
61	62	63	64	Students should write direct to manufacturer.					

(35) EQUIPMENT BOOK: Eight-page bulletin CG-15 describes and illustrates products manufactured by *Le Roi Div.*, Westinghouse Air Brake Co. Specifications are given of Le Roi's complete line of portable air compressors; Tractair, a combination compressor-tractor; Newmatic air tools, including breakers, drills, tampers, and spades; and CRD one-use drill bits. Photographs include many construction scenes.

(36) FILTER CLOTH: *National Filter Media Corp.'s* Bulletin 10 gives complete technical data on all types of filter cloth. Fabrics covered include Nylon, Dacron, Vincel, Orlon, Dynel, Teflon, Saran, cotton, glass, polyethylene, and special filter papers. Data covers chemical resistance, corrosion resistance, abrasion resistance, and available yarn forms for each type of cloth.

(37) CAT ATTACHMENTS: Prime mover tools offered by *Caterpillar Tractor Co.* for its equipment are listed in Form DE754. Illustrated booklet shows attachments for crawlers, wheel units, Traxcavators, and motor graders.

(38) WELDING DATA: The 180-page 1958 edition of the pocket-sized "Welding Data Book" is available from *Eutectic Welding Alloys Corp.* The guide covers 120 welding rods, electrodes, and welding compounds.

(39) BOTTOM DUMP: An entirely new kind of bottom dump trailer called the PW20 has been announced in an 8-page booklet now available from *Athey Products Corp.* This 40-ton-capacity trailer features a rear door which opens simultaneously with the bottom doors. The 5-ft clearance of the door allows the PW20 to ride out over the dumped load, eliminating the need for pusher units. Matched to the Caterpillar DW20 Tractor, the PW20 has speeds up to 32.1 mph and can make 90° turns in 38 ft 4 in.

(40) CAR SHAKER: Features of the Allis-Chalmers car shaker are described in Bulletin 07B7221B, released by the *Allis-Chalmers Mfg. Co.* Car shaker is designed for safe, fast, economical pushbutton unloading of granular material from open, hopper bottom gondola cars. Some of the advantages offered: lift bars have conveniently spaced holes for ease in attaching hooks or shackles; unit hangs level from hoist or crane, facilitating centering on car eaves; simplified, two-bearing, completely enclosed mechanism reduces maintenance; and wide-faced shoes are designed to fit any standard U. S. hopper-bottom gondola car or orecar. Photographs and cross-section diagrams are included.

(41) EXPLOSIVES: "Lock 'em up! so kids can't get hurt" is the theme of a new poster currently distributed by the *Institute of Makers of Explosives* to all users of blasting caps. Stressing safety, the poster cautions all users of caps to take measures in preventing these detonators from falling into the hands of children.

(42) S-H CLASSIFIERS: *Western Machinery Co.* has prepared 20-page Bulletin CI-B33, featuring Wemco S-H classifiers, to provide engineers and operators with useful technical data and information on wet classification. Information serves as a guide toward solution of metallurgical and economics problems encountered in various industries. The illustrated catalog includes a capacity table and a shipping weights and volume guide. Included also are principles of operation and design, operating notes.

(43) SOIL SAMPLING EQUIPMENT: New 24-page Bulletin 300 illustrates and describes soil samplers and accessories made by *Sprague & Henwood Inc.* Engineering improvements and new devices are shown.

(44) PILE HAMMER: A completely self-contained, easily transported, one-man-operated diesel pile hammer which needs no auxiliary equipment is now available from *Link Belt Speeder Corp.*, subsidiary of Link Belt Co. The new hammer eliminates the need for compressors, boilers, high-pressure hose, fresh water supply, and other auxiliary equipment required for conventional air or steam hammers. The hammer is available in three models which can be used on any make of power crane.

(45) DUST FILTER: *Day Co.'s* Bulletin 599 has facts on the Day Reverse Jet dust filter. This 28-page illustrated book outlines aids in solving plant dust control problems. Brochure contains schematic operating diagrams, performance curves, a comparison of reverse jet and conventional type filter performance, and air engineering data. Book covers planning and arrangement of filters to meet specific requirements and explains self-adjusting reverse jet blow rings. Catalog is indexed for easy reference.

(46) RADIOISOTOPE-EXCITED LAMP: Model 535 radioisotope-excited lamp, just introduced by *United States Radium Corp.*, provides illumination for periods up to 10 years with no power or maintenance required. Unit is 6 in. long, has a 5-in. luminous face, and is clearly visible at 500 yd. The 10-lb Model 535 has a single, highly-efficient port. One color of emission per lamp (blue, green, yellow or orange-red) is provided.

(47) FIBER FILTER: Samples and test data are now available of heavy duty Polymax fiber filter cloth from the *National Filter Media Corp.* The filter cloth is made of the new olefin polymers known as high polyethylene. Polymax has a softening temperature of 260°F. The fabric is finished so that exposure in the 230° to 240°F range results in minimum shrinkage.

(48) V-BELTS: A 14-page booklet, S-51106, describing machines and processes used in the production of V-belts has been issued by the *Goodyear Tire & Rubber Co.* The brochure covers rubber compounding, preparation of fabric, building steps, curing, and finishing.

(49) PUMPING UNITS: Pumping units for foundation testing and core drilling are detailed in *Sprague & Henwood Inc.'s* 8-page, Bulletin 370. Booklet offers descriptions and specifications on pumping units for soil sampling, core drilling and pressure grouting. Units are available with any one of four types of power units and several types of drive assembly including several models that are normally furnished with 4-speed transmission for a wider choice of capacity and pressure.

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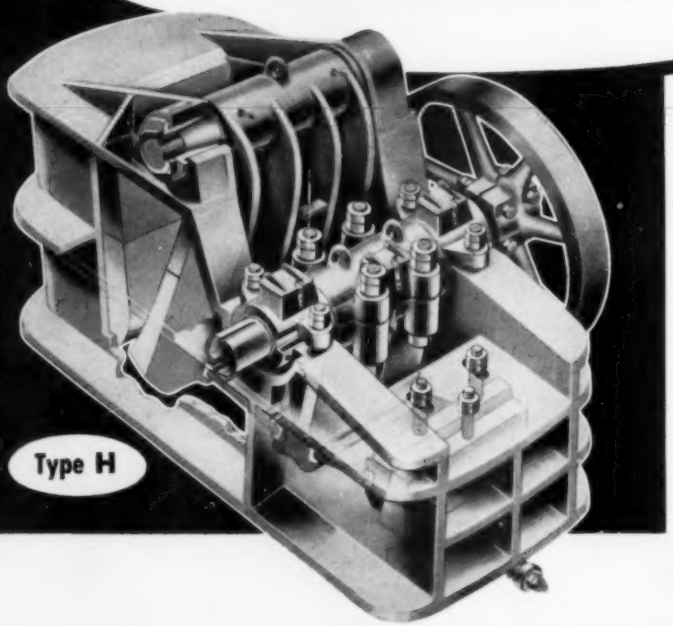
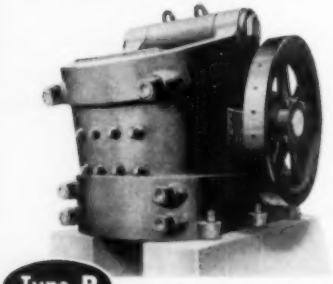
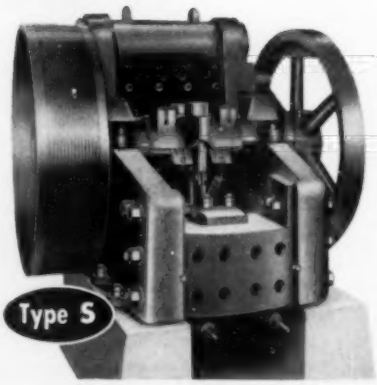
Traylor-MADE
JAW CRUSHERS
for the mining industry







Four types of the hundreds of Traylor Jaw Crushers used throughout the world — with over half a century of engineering experience and know-how built into each. Features include non-chokable smooth-faced curved jaw plates, which allow for greater capacity at fine setting and longer life of wearing plates. Frames are reinforced at critical points to provide strength without excessive weight. Write for bulletins: Type H-HB, 3105 — Type R, 1123 — Type S, 1122.

Traylor

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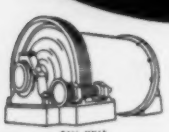
Sales Offices: New York — Chicago — San Francisco

Canadian Mfr.: Canadian Vickers, Ltd., Montreal, P. Q.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APRON FEEDERS

PRIMARY GYRATORY CRUSHERS

JAW CRUSHERS

SECONDARY GYRATORY CRUSHERS

hard and tough to the core...

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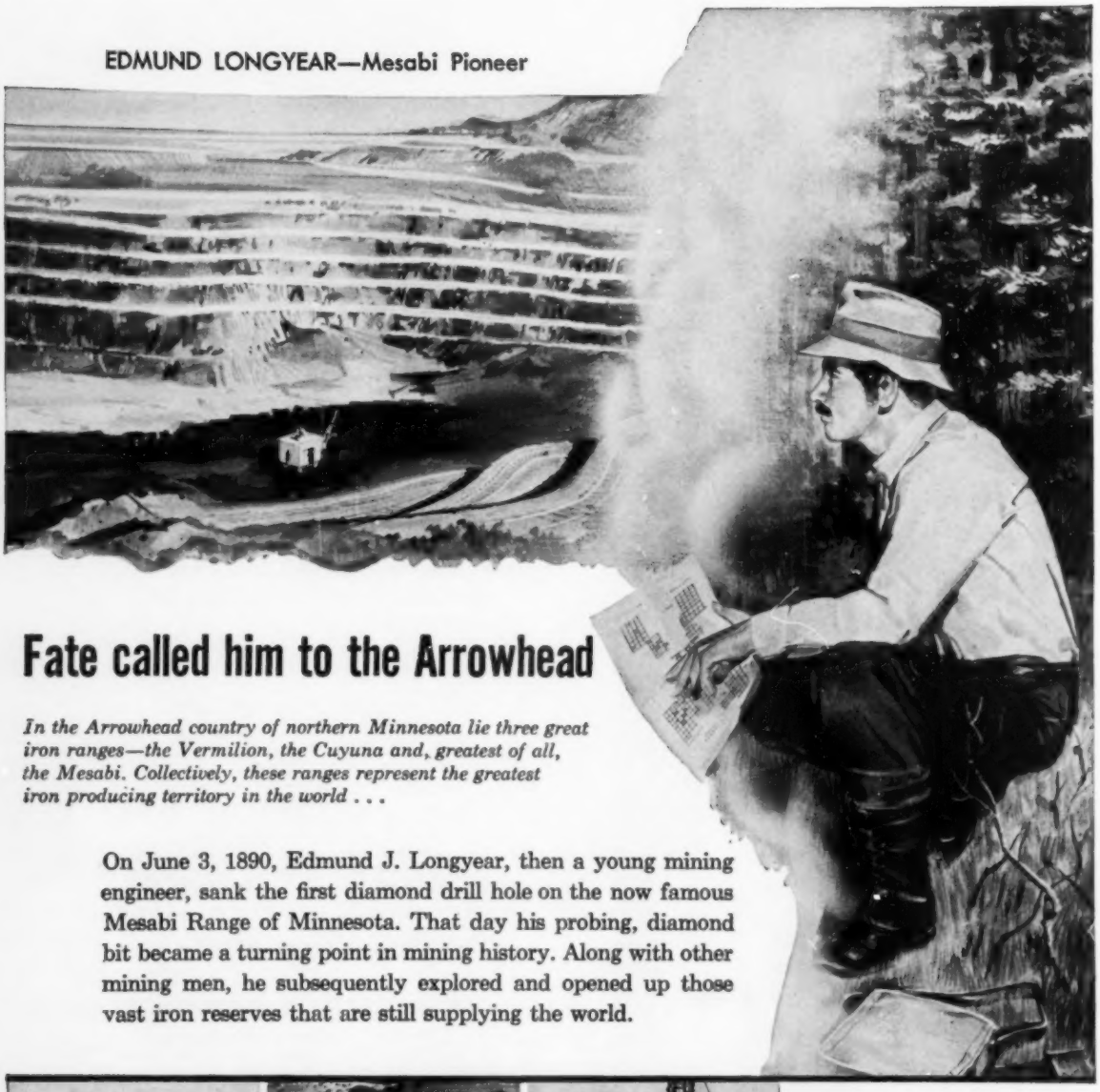
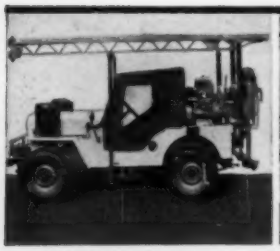
EDMUND LONGYEAR—Mesabi Pioneer



Fate called him to the Arrowhead

In the Arrowhead country of northern Minnesota lie three great iron ranges—the Vermilion, the Cuyuna and, greatest of all, the Mesabi. Collectively, these ranges represent the greatest iron producing territory in the world . . .

On June 3, 1890, Edmund J. Longyear, then a young mining engineer, sank the first diamond drill hole on the now famous Mesabi Range of Minnesota. That day his probing, diamond bit became a turning point in mining history. Along with other mining men, he subsequently explored and opened up those vast iron reserves that are still supplying the world.



DIAMOND CORE DRILLS
A complete line of core drills—surface, underground and mobile—in many models, plus drilling equipment and supplies.

GEOLOGICAL, MINING CONSULTANTS
A full staff of geologists and mining engineers serving mining companies and mining departments of countries all over the world.

CONTRACT DRILLING
Highly trained drill crews using modern Longyear equipment for mineral exploration and development and foundation testing.

Today, the E. J. Longyear Company provides the mining industry with every type of service: mining engineering, geological and photogeological surveys, contract core drilling, and the manufacture of diamond core drills and equipment.

Branch offices and an active sales organization covering 56 countries, give Longyear representation in every part of the free world.

Longyear

E. J. Longyear Co., CABLE LONGCO
General Offices: Minneapolis, Minn.
Canadian Longyear Ltd., North Bay, Ontario
Longyear et Cie, Paris, France
Longyear N.V., The Hague, Holland

First Bauxite Concession Granted by Panama

Exclusive exploration and mining rights to a large area of western Panama near the Costa Rican border have been granted to Kaiser Aluminum & Chemical Corp. by the government of Panama. Preliminary studies indicate extensive deposits says Kaiser, adding that it expects Panama to become a major source of the ore.

Rare Metals Buys Mercury Mine

Altoona Quicksilver mine in Trinity County, Calif., a non-producer since 1902, has been purchased by Rare Metals Corp. of America for a reported sum of more than $1 million. Tests confirm 40,000 tons of ore containing a third of a flask per ton, and a good potential is also said to exist. Before sale of the mine, developers spent some $300,000 on its reconditioning. Rare Metals is expected to erect a 100-tpd mill on the mine site for about $400,000.

Crucible Steel Acquires Joint Titanium Firm

Crucible Steel Co. of America has acquired 100 pct ownership of Rem-Cru Titanium Inc., a company it organized in 1950 as a joint venture with Remington Arms Co. The acquisition is subject to SEC approval. Discussing the move, Crucible President Joel Hunter said "It has become increasingly evident in recent months that the titanium business can best be conducted as a part of the specialty steel business." Remington has not commented on its departure from the field.

Brazilian Itabirite Ores Under Study

The vast deposits of itabirite iron ores in the state of Minas Gerais, Brazil, are being surveyed for the Brazilian government by Armour Research Foundation for economic evaluation and long-range planning. Major problems concern development of "suitable beneficiation techniques for extensive exploitation" and "adequate and economical marine transportation to markets."

Cesium Found in Lithium Orebody

Pollucite, principal cesium ore, will be produced at the rate of 1000 to 3000 tons per year from an orebody at Bernic Lake, Man., 85 miles north of Winnipeg. Montgary Explorations Ltd. reports its estimated 8-million ton spodumene holding also contains about 100,000 tons of pollucite. The cesium mineral also contains 0.5 to 0.9 pct rubidium.

American Potash to Explore Manganese Property

American Potash & Chemical Corp. plans to investigate manganese deposits covering more than 10,000 acres near Batesville, Ark. According to the company, favorable results would result in the formation of a new company to undertake commercial production. American Potash would hold a 55 pct interest. Operation on a limited scale has been carried on for some years by four Arkansas companies.

If You Use Blasting Caps

EXAMINE THESE FEATURES

1. **DEPENDABLE FIRE**—Special alloy is used as the bridge wire in the firing element of Hercules Electric Blasting Caps. Wire is noncorrosive.

2. **ENGINEERED SHELL**—Bronze shell of a Hercules cap goes through fifteen separate operations while it is being expertly shaped.

3. **TOUGH, HIGH DIELECTRIC INSULATION**—Leg wires of Hercules caps are coated with plastic insulation for outstanding toughness, resistance to abrasion, superior dielectric qualities.

4. **SECURELY ANCHORED**—A cast sulfur plug in the upper part of shell anchors entire firing mechanism in place.

5. **WATERTIGHT WATERPROOFING**—A special Hercules waterproofing formulation minimizes the possibility of moisture or dampness penetration.

6. **DOUBLE-PACKED WALLOP**—Bridge wire extends into the priming charge and makes positive contact to give rapid ignition.

7. **DOUBLE-PACKED WALLOP**—Bridge wire extends into the priming charge and makes positive contact to give rapid ignition.

HERCULES BLASTING CAPS

Partners in Dependability with Hercules® Explosives

HERCULES POWDER COMPANY
INCORPORATED
Explosives Department: 900 Market Street, Wilmington 99, Delaware
Birmingham, Chicago, Duluth, Hazleton, Joplin, Los Angeles,
New York, Pittsburgh, Salt Lake City, San Francisco

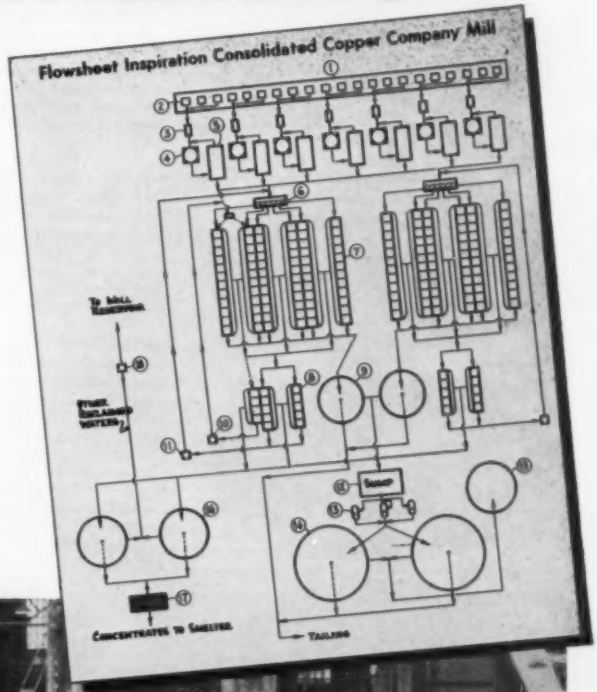
XR58-1

INSPIRED METALLURGY*

extends INSPIRATION'S *reserves*

A new lease on life has been achieved by Inspiration Consolidated Copper Company, Inspiration, Arizona, through the complete rehabilitation of facilities idle for over a quarter of a century. Below are some of the highlights of the operation. For complete details, write for Wemco Bulletin F5-B30.

- **Dual Process, using acid leach for oxide fractions and flotation for sulphides.**
- **Increase in capacity, originally 10,000 tons, now 15,000 tons of ore per day.**
- **Simple flow sheet, with unique test circuit providing for a 2,500 t.p.d. pilot plant within the commercial circuit.**
- **Wemco-Fagergren flotation machines used throughout; 144 cells for roughing, 24 for cleaning.**



Wemco Fagergrens are controlled from a console, with a separate indicator for each unit.

WEMCO

WESTERN MACHINERY COMPANY
650 FIFTH STREET
SAN FRANCISCO 7, CALIFORNIA

Representatives in principal cities

1957 has been a year of contrasts.

Significant advances in technology, the completion of a substantial portion of our program to expand our productive capacity in the U. S. and Canada and the strengthening of our marketing organization are all tangible achievements which will bring us both immediate and long-term benefits. On the other hand, a generally lower activity in new projects coming in has emphasized the narrowing profit margins faced by most businesses and points up our insistence on improving designs, reducing costs and increasing efficiencies.

Abroad, the picture is bright. Our subsidiaries report current high levels of business and there is great optimism for the future. Of particular interest is the success of our newest family member, Dorr-Oliver Pty. Ltd. of Australia, which opened its doors on January 1 of this year and by mid-year had far surpassed expectations. Growth of Dorr-Oliver (India) Ltd., another of our newer associates, has also been noteworthy, with the recent addition of local manufacturing facilities justifying still greater optimism.

SUGAR — In 1957 a total of 42 RapiDorr Clarifiers and 48 Oliver-Campbell Cane Mud Filters were sold to the cane sugar industry. A significant aspect of this outstanding record has been the increasing participation of our subsidiaries and representatives abroad. They are locally manufacturing, in some instances for the first time, 31 of these machines in Argentina, Brazil, England, France, Germany, India, the Philippines and South Africa.

POLYETHYLENE — The first Merco Pressure Centrifuges went into operation early last year removing catalyst from liquid polyethylene at capacities considerably in excess of original expectations. Overseas, British, Italian and German producers ordered Pressure Centrifuges for similar application in both new commercial scale and pilot plants.

SANITATION — One of the highlights of the year was D-O activity in the waste water disposal field. Four major new developments — all ideally suited for smaller plants — were introduced. The SpiroVortex System which is a complete treatment process akin to activated sludge, the Degritting Clarifier and Clarigester and the DorrClone Classifier as applied to sewage degritting have already been commercially proven at plants in the western U. S. First installations of the CompleTreator, a package plant to serve a population of 150, are now operating with some 30 additional units scheduled to start up in 1958.

Our subsidiary in the Netherlands has marketed equipment for facilities as far distant as Norway, Iraq and India, while new or enlarged D-O equipped domestic installations sold in 1957 can be found from New York City to Los Angeles and San Antonio, Texas to Fairmont, Minnesota.

GENERAL METALLURGICAL — Applications of the DSM Screen, first introduced in 1956, continued to grow in virtually every field we serve. One of the most promising has been magnetite recovery in heavy media cyclone plants on the Mesabi Range. Also new is the swing-type agitator for the American Filter — a development particularly applicable to filtration of heavy metallurgical slurries.

Following the trend noted in previous years, widespread acceptance of the Slurry Mixer by the cement industry and the Thickener — American Filter combination by the coal industry continued again last year. In Germany, France, India and Australia flue dust clarification and recovery contributed materially to our business and in Canada a substantial volume of Dorr-Oliver-Long shaft equipment and mine cars was purchased for underground mines.

PLANT ENGINEERING—At the year's end, design of a granular fertilizer plant for India and sections of a new Cuban nickel recovery plant were partially completed, and construction of three D-O designed phosphoric acid or fertilizer plants was progressing in Venezuela, England and Montana. During the year a 200,000 ton per year triple superphosphate plant in Florida and a Norwegian phosphoric acid installation were put into operation and brought up to design capacity in near record time.

FLUOSOLIDS SYSTEMS — Also in the fertilizer industry two western producers ordered the first FluoSolids Systems to be used for calcination of phosphate rock. Designed to handle a total of 1,500 tons per day, these installations were the direct result of successful field tests using a portable fluidized bed pilot plant. During the year other FluoSolids Systems were ordered to dry limestone and blast furnace slag in the U. S., roast copper matte in Belgium, calcine clay in Scotland, decompose copperas in England, and roast pyrite for a Japanese paper mill and an Italian sulfuric acid manufacturer.

The largest FluoSolids System for fine coal drying, handling over 600 tons per hour, went into operation during the third quarter at a new eastern preparation plant, and construction is nearing completion on a second similar, but smaller, installation. In the realm of unusual applications is a unit drying a highly-corrosive chlorinated hydrate at an eastern chemical plant.

WATER TREATMENT — In the southwestern United States the DorrClone Classifier has been used with notable success for the desanding of municipal well water supplies. For small plants the PeriFilter System with a single pre-treatment unit and split filter provides economical unitized water treatment.

Major expansions of the Louisville, Kentucky and Fort Worth, Texas treatment facilities will be D-O equipped as will new municipal plants at Springfield, Ohio; Peoria, Illinois; and Delhi, India. New industrial treatment installations will serve pulp mills in South Carolina, India and Venezuela and an Indian fertilizer plant.

PETROLEUM — Another modification of the familiar DorrClone Classifier is the Clay-Jector, latest development for control of drill mud weights. Noteworthy economies are possible using this unit which mechanically rejects undesirable drilled solids while recovering valuable barites for reuse.

CHEMICAL — A substantial amount of D-O equipment of all types has been incorporated into the unique flowsheet of a new astrakanite recovery plant in the Chilean nitrate fields. In Germany and the United States, Horizontal Filters have been widely applied to dewatering and washing of fine organics as well as highly corrosive inorganics, and around the world filters of both standard and special construction were ordered for an almost endless variety of services.

COPPER AND URANIUM—Last year substantial amounts of D-O processing equipment were purchased for new and enlarged copper mills in South America, Mexico, the Belgian Congo and United States and new uranium mills in Australia, United States and Canada. A new and improved design and method of fabrication of stainless steel rake Classifier blades was developed. Although conceived initially for the uranium industry this design is broadly applicable to classifications involving corrosive solutions. Certainly no summary of 1957 accomplishments would be complete without mention of the Chemical Engineering Achievement Award presented last month to a group of companies including Dorr-Oliver for their contribution to extractive metallurgy of atomic age metals. Interestingly enough, D-O was one of the very few engineering equipment organizations selected for the award.

With several years of expansion and enormous activity behind us, the current business plateau provides a much needed opportunity to consolidate and catch our breath. The real challenge will be to increase the spread between income and outgo through more efficient operation — while accelerating the rate of our technological advances. I am confident we can, and will, do both.

J. D. Hitch, Jr.
President

November 18, 1957

DorrClone, FluoSolids, PeriFilter and RapiDorr T.M. Reg. U. S. Pat. Off.

Anaconda to Enter Iron Mining

The Anaconda Co. has made a positive step toward eventual production of iron ore. Through its Canadian subsidiary, Anaconda Co. (Canada) Ltd., the major copper producer has purchased for $10 million certain claims and properties of an iron field in northern Ontario, about 125 miles northeast of Nipigon, a Lake Superior port.

The purchase price will be paid in installments stretching into 1975, unless the properties go commercial. In this case, payments will be accelerated.

Anaconda reports that more exploration is necessary, as well as investigation of metallurgical processes. Large tonnages of low grade magnetite averaging 25 to 30 pct Fe have been discovered, and the material is amenable to processing that will produce a 64 to 68 pct Fe concentrate.

A new company will be formed to take charge of the properties and will probably be called Anaconda Iron Ore Ltd.

American Metal and Climax Molybdenum Plan to Merge

A plan for the consolidation and merger of the American Metal Co. Ltd. and Climax Molybdenum Co. has been approved by directors of the two concerns. The surviving corporation would be American Metal Climax Inc. Upon approval of stockholders, the merger would become effective early in 1958.

Under the merger agreement three shares of American Metal Climax Inc. common stock would be issued for each share of outstanding Climax Molybdenum stock but no shares would be issued for the Climax shares owned by American Metal. None of the outstanding shares of American Metal common would be changed except for a change from no par value to $1 par value.

H. K. Hochschild will remain honorary chairman of the board. A. H. Bunker, now president of Climax, would become chairman of the board of the new corporation. H. A. Vogelstein would be president.

Boron Output Pushed 30 Pct Higher

U. S. boron production was increased 30 pct with the opening of the new U. S. Borax & Chemical Corp. open pit mine and refinery at Boron, Calif. It is expected that this $20 million project, which has required more than two years to complete, will ultimately produce 70 pct of the Free World's total supply, the company claimed recently.

In this operation, borax is mined by the open pit method for the first time. The 175-ft deep, 1400-ft wide pit, from which 9 million tons of overburden has been removed, exposes the largest deposit of sodium borate known and permits almost complete ore recovery.

Boron has become an important ingredient in the manufacture of such products as pharmaceuticals, porcelain enamels, plastics, steel, glass, agricultural chemicals, flameproofers, fire extinguishers, preservatives, and gasoline additives. The latest development has been boron's use as an ingredient of a new high energy aircraft fuel.

U. S. Borax & Chemical Corp.'s new open pit mine and refinery covers an 80-acre site at Boron, Calif., in the Mojave Desert. The $20 million facilities took two years to complete and involved the removal of 9 million tons of overburden.

New Domestic Rutile Source

A $1.25 million rutile facility built by Metal & Thermit Corp. at Hanover County, Va., is expected to become an important domestic source of the titaniferous ore. Situated on an 800-acre tract, the processing plant will have an ore capacity of 100 tph, and is scheduled to produce 5000 tons of rutile yearly.

By 1958, Metal & Thermit expects the Hanover plant will supply 12 pct of U. S. requirements. Ore reserves are estimated at a ten to 12-year supply, depending upon industrial demands.

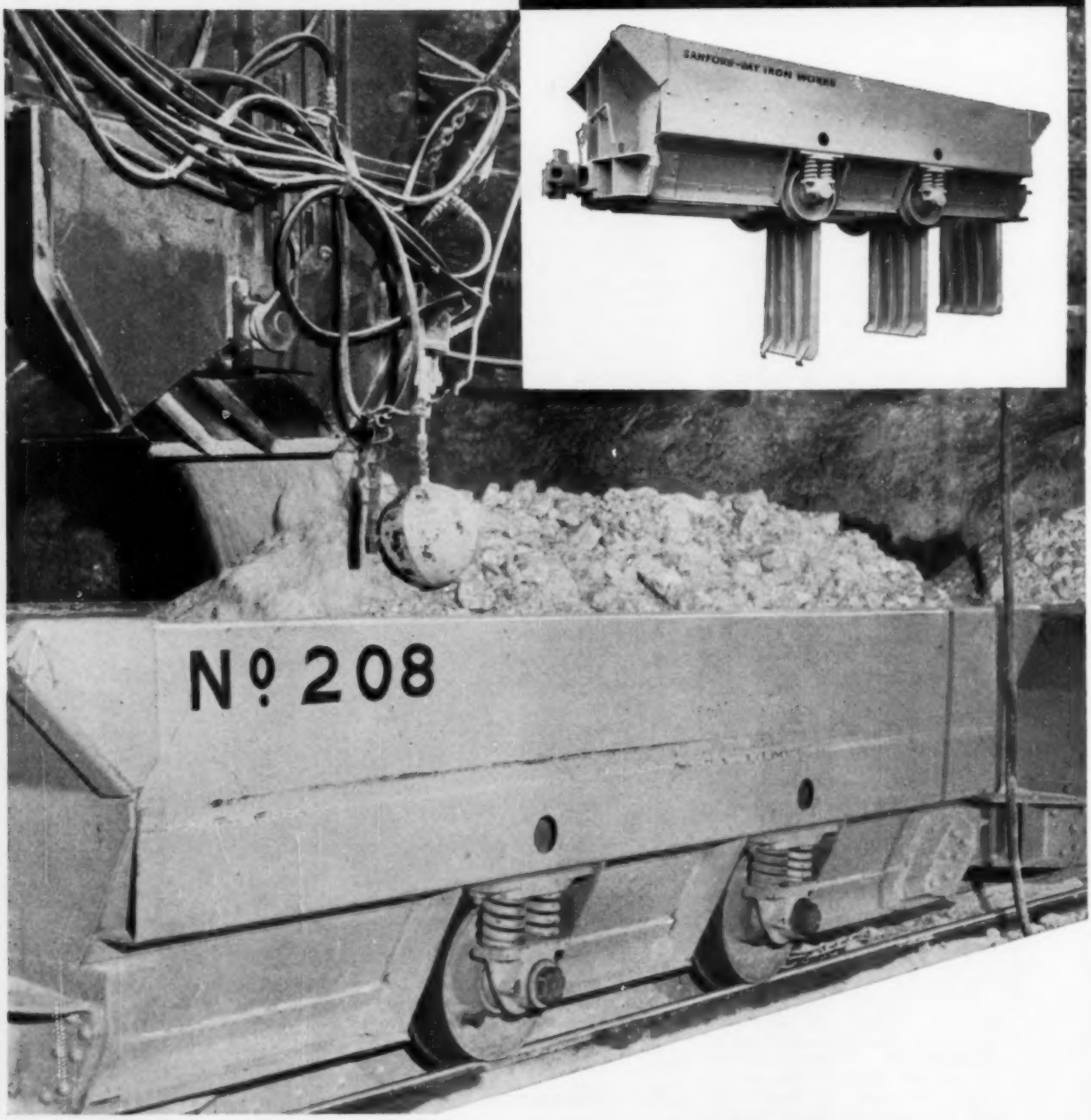
Domestic consumption of rutile has increased more than 350 pct in recent years, and amounted to 50,000 tons in 1956 compared with an annual average consumption of 11,000 tons in the 1947 to 1951 period.

Milling Process

Raw rutile-ilmenite ore is fed into an outdoor hopper which discharges onto a belt conveyor carrying the ore into the plant.

(Continued on page 28)

These S-D AUTOMATICS



SANFORD-DAY

Knoxville, Tennessee

"SUPER MARKET FOR MINE CARS" — *all types* * PRECISION WHEELS * "BROWNIE" HOISTS, CAR RETARDERS, SPOTTERS, PUMPS AND OIL SPRAY SYSTEMS * GISMO SELF-LOADING TRANSPORT that loads *(mucks)* in development or production . . . transports . . . supports 2 to 5 jib mounted drills . . . back fills . . . moves boulder rocks . . . makes its own roadways and cleans up completely — a new method of hard rock mining offering a tremendous reduction in cost per ton!

have been in service at U. S. Potash 3 years...working 363 days per year, two shifts per day on a seven-mile run!

Another example of efficient main-line haulage with S-D "Automatic" Bottom Dumping Mine Cars!

"Because of their low center of gravity and balanced rugged construction, they hold the track exceptionally well at speeds up to 30-miles-per-hour," reports Mr. Earl H. Miller, resident manager of the Carlsbad, N. M., mining operation of United States Potash Company, Division of United States Borax & Chemical Corporation.

"Also," Mr. Miller continues, "the door operation is very good, allowing the cars to do a good job of self-cleaning." How does the maintenance costs of these cars compare with conventional type ore cars? "We have had very low maintenance costs on the S-D 'Automatics' compared to others we are using."

Note in pictures above and on page at left that mining management at U. S. Potash have further mechanized their main-line haulage with an automatic loading station. We are understandably proud that S-D "Automatics" were chosen for this U. S. Potash operation that incorporates the latest developments in modern simplicity and efficiency. In addition to this installation, S-D "Automatics," like the car illustrated at right, are hauling hard rock in several western mines at tremendous savings! Write us today for complete information. *Sanford-Day Iron Works, Inc., Knoxville, Tennessee*

1/4 to 1/2 TON MORE CAPACITY
Twin Latches FOR SAFE AND SURE LATCHING
SANFORD-DAY IRON WORKS
Safety Sealed AGAINST DUST LEAKAGE

(Continued from page 25)

The ore is reduced to —1 in. by a hammermill and then carried by a second belt conveyor to a rod mill, in closed circuit with a vibrating screen, where —20 mesh grinding is done. Hydraulic cyclones are used to deslime the ore slurry, which is then pumped to the first step of heavy mineral concentration, which consists of spiral concentrators set up in two stages.

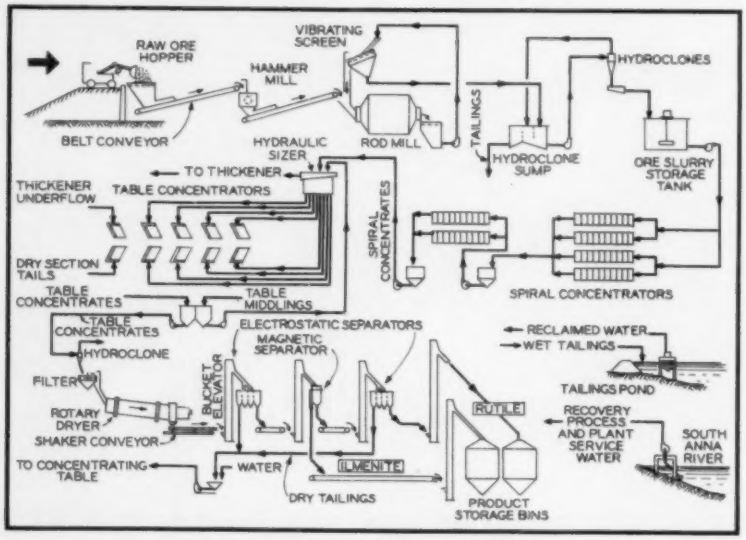
Heavy concentrates are then pumped to a hydraulic sizer, the discharge of which flows by gravity to concentrating tables. Sizer overflow goes to a thickener, underflow being fed back to a special concentrating table.

Concentrated material from the tables is pumped to a small dewatering hydraulic cyclone, and then on to a filter which discharges the cake onto a rotary drier.

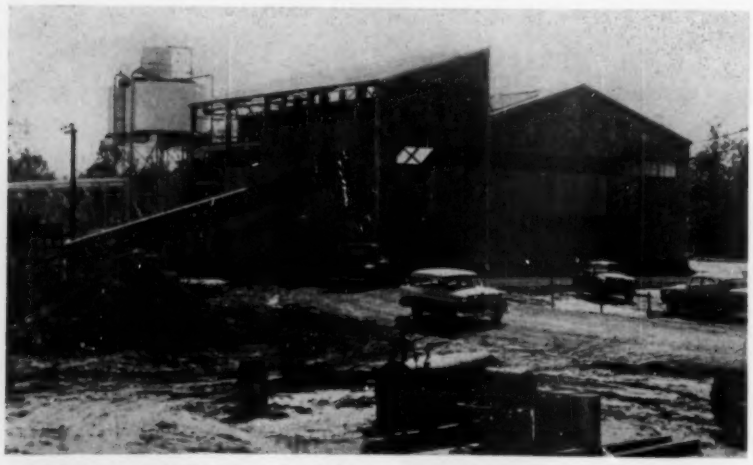
Dried concentrates are fed through a series of bucket elevators and conveyors to electrostatic and magnetic separators set up in series. First electrostatic separation serves principally as a cleaner for the dry concentrates, removing tailings from the wet process concentrates. Cleaned concentrates are processed through a magnetic separator, which removes the ilmenite. The remaining dry concentrates, consisting mainly of the non-magnetic rutile, are fed to another electrostatic separator for final cleaning.

The rutile and ilmenite are stored in separate steel bins, from which the material is packed in bags or bulk-loaded into trucks.

Wet tailings are pumped to a tailings pond, and the clear overflow water reused. Additional water needs are supplied by a pump station set up on the bank of the nearby South Anna River.



Hanover Heavy Minerals Plant. Metal & Thermit Corp.



Only two states, Florida and South Carolina, were domestic rutile sources until this new facility was opened by Metal & Thermit Corp. at Hanover, Va.

Utah Has Large Phosphorus Potential

San Francisco Chemical Co., jointly owned by Stauffer Chemical Co. and Mountain Copper Co. Ltd., expects its undeveloped deposit of phosphate rock at Vernal, Utah, some 19 power line miles from Flaming Gorge, may become a major source of phosphorus within the next few years. The possibility of quick development will be increased when the Flaming Gorge Dam, now under construction, is completed.

San Francisco Chemical holds all rights to the deposit, which covers some 15,000 acres. Indicated phosphate rock reserves, averaging 21 pct P_2O_5, approximate 700 million tons. The company has been proving the deposit over the past several years through extensive core drilling and tunneling.

Stauffer Chemical is present owner of an open pit phosphate mining project at Leefe, Wyo., which is operated by San Francisco Chemical. This mine supplies ore to Stauffer fertilizer plants in the West and to Western Phosphates Inc. at Garfield, Utah. The Leefe deposits have an estimated useful life of ten to 15 years. The Vernal phosphates, which also can be open pit mined, are being evaluated both as additional raw material and as future reserves.

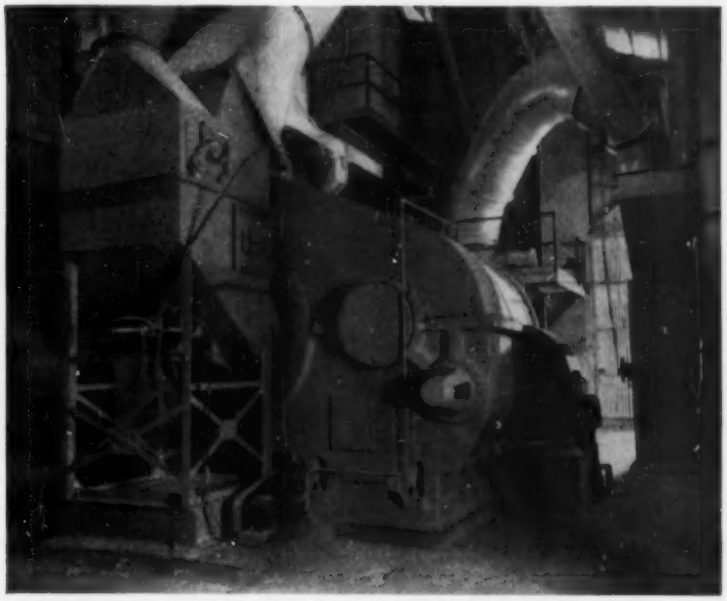
To make the Vernal deposit usable would require construction of a beneficiation plant at the mining site. A process has been developed which will upgrade the ore for either electric furnace or fertilizer use. The method has been used at Leefe, and it is anticipated that a substantial tonnage of the Vernal ore will be treated at Leefe in 1958 to prove the process on full-plant scale.

If power becomes available from the Flaming Gorge Dam, it would be feasible to locate electric furnaces at the mining site to create an integrated plant.

G. D. Clyde, Governor of Utah, recently visited the Vernal deposits. Bulk of ore can be open-pit mined.

LOWER
production costs with a
KENNEDY
air swept grinding system

The KENNEDY Air Swept Tube Mill Grinding System is the ultimate in high production and low operating cost. The experience of the many owners of KENNEDY Mills has shown that the cost of this mill can be paid in a few years with the savings in maintenance and power alone!



KENNEDY 10′ x 15′ Integral Gear Drive Air Swept Ball Tube Mill and #93 Exhauster Fan in service at the American Agricultural Chemical Co., Pierce, Florida.

HERE ARE A FEW OF THE REASONS FOR THE ECONOMY AND POPULARITY OF KENNEDY PULVERIZING SYSTEMS...

REDUCED MAINTENANCE • Tramp iron and other foreign material cannot damage the system. Years of operation are assured before parts (except for grinding balls) require replacement.

CONTINUITY OF OPERATION • Lubrication and replacement of grinding media is accomplished without shutdown or interruption of production.

MINIMUM POWER • Careful design and construction and a proven pressure lubrication system insure a high mechanical efficiency.

HIGHER PRODUCTION • Single grinding units are built for capacities to 100 tons per hour. Production and fineness remain constant, month after month.

LOWER OPERATING COSTS • Dependability of equipment and reliable automatic feed control assure high production with minimum manpower.

CAPITAL SAVINGS • No magnetic separators are required. KENNEDY units require less structural steel and floor space per ton of product.

FLEXIBILITY OF DESIGN • KVS Air Swept Grinding Systems are available for a wide range of capacities and products.

KVS

Send now for full details on KENNEDY Size Reduction Equipment.

KENNEDY • VAN SAUN

MANUFACTURING & ENGINEERING CORPORATION

TWO PARK AVENUE, NEW YORK 16, N.Y. • FACTORY: DANVILLE, PA.

"Not merely to sell; but to serve . . . not only to make good steel products; but to make them still better . . . not only to fulfill today's requirements; but to anticipate tomorrow's—these are the principles that constantly guide CF&I."

G. F. Fraunz
President

We've taken our own advice

When any business is "soft", management often uses this period to clean house. All operating methods are examined carefully with an eye toward increasing efficiency by revising or eliminating those practices that hamper productivity—practices that could not be corrected during peak periods.

In the past, there have been times when the demand for CF&I Grinding Balls has exceeded our capacity, and you have had to wait for deliveries. More recently, demand has been off somewhat, and we have utilized this period to improve our own production efficiency, and new equipment has been added to increase our volume. Now we are in a position, when the demand again picks up, to offer you greater production and quicker deliveries from our enlarged stocks of grinding balls. Thus, we have "anticipated tomorrow's requirements"—we have taken our own advice.

We feel sure that most grinding mill operators follow these procedures—that they *do* make a drive toward increased efficiency during slack periods, so that they will be all the more prepared for periods of intensive output. To help you do this, CF&I has instituted this two-pronged service program:

1. **Engineering Service . . .** CF&I's Mining Products Engineers are ready to analyze your grinding mill problems; make recommendations on how you can improve your operations.
2. **Technical Information . . .** CF&I is currently preparing a series of advertisements containing technical information on ways to improve grinding mill operations.

Take advantage of our Engineering Service and look for the ad series in this publication . . . they'll be appearing regularly during 1958 and reprints will be available. The nearest CF&I sales office will be glad to service your needs.

Other CF&I Steel Products for the Mining Industry

CF&I Grinding Rods • CF&I Rock Bolts • Wickwire Rope
CF&I Mine Rails and Accessories • CF&I Industrial Screens
Rexlock Fence and Fabric • Grader Blades and other Cutting Edges

FORGED STEEL GRINDING BALLS
THE COLORADO FUEL AND IRON CORPORATION

Albuquerque • Amarillo • Atlanta • Billings • Boise • Boston • Buffalo • Butte • Casper • Chicago • Denver • Detroit • El Paso • Ft. Worth • Grand Junction Houston • Kansas City • Lincoln (Neb.) • Los Angeles • New Orleans • New York • Oakland • Oklahoma City • Philadelphia • Phoenix • Portland • Pueblo Salt Lake City • San Antonio • San Francisco • San Leandro • Seattle • Spokane • Wichita

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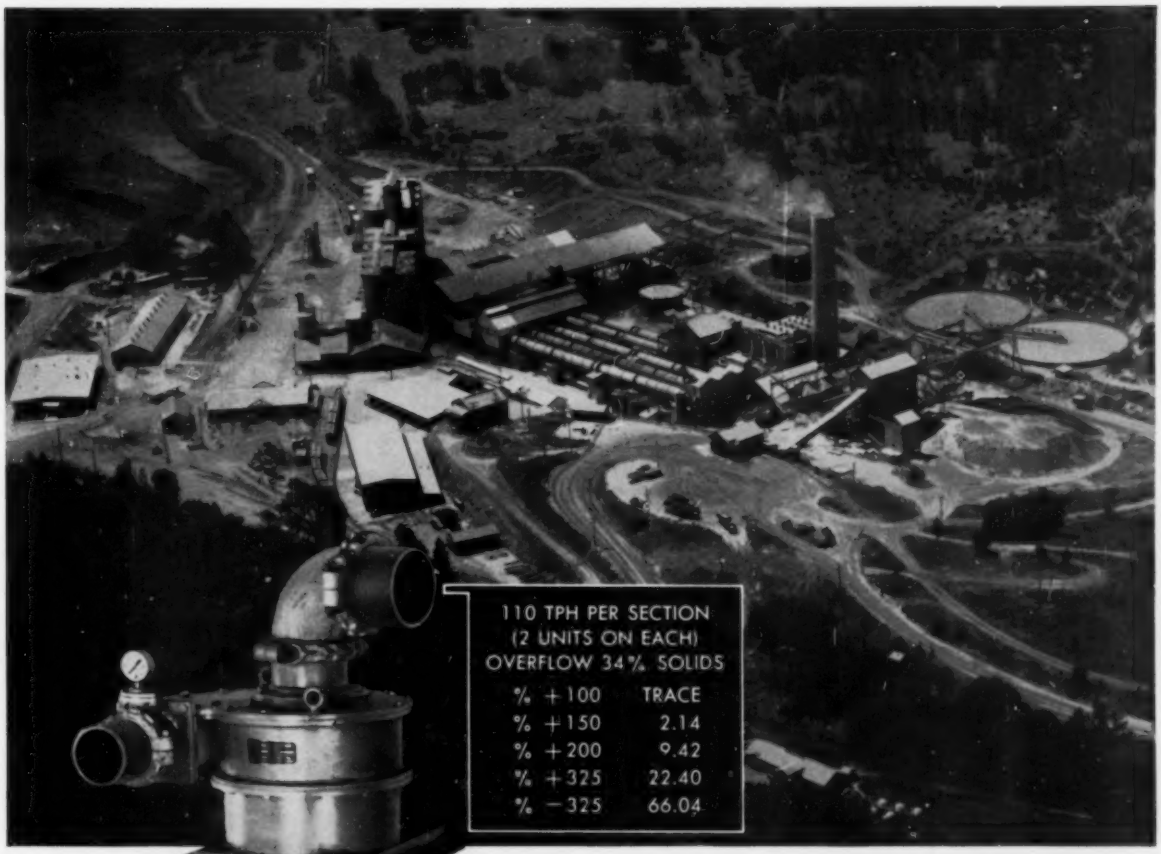

110 TPH PER SECTION (2 UNITS ON EACH) OVERFLOW 34% SOLIDS	
% +100	TRACE
% +150	2.14
% +200	9.42
% +325	22.40
% −325	66.04

closed-circuit classification to 88% −200 mesh at 34% solids with Krebs Cyclones

Calaveras Cement Company, the largest mine ever to operate in California's historic Mother Lode, makes another major contribution to milling technology. In 1956, capacity per section at Calaveras was stepped up from 80 to 110 tons per hour. This called for better classification. Krebs Cyclones, model D20B, especially fitted to meet the objectives were installed. Tramp sizes in the final product are only a trace on 100 mesh even with high density at 34% solids compared to a previously fluctuating 11 to 16% solids. Only 26% as much water is required. Kwh per ton for classification and pumping to the thickeners has dropped 38%. Pressure requirement at cyclone inlet is 11 psi. Krebs Cyclone operation is simple; grind-out time on shutdown is eliminated. Maintenance after a year has been negligible.

"For complete details see Calaveras article October 1957 MINING ENGINEERING pp. 1109-1111"

EE PRODUCTS

EQUIPMENT ENGINEERS INC.

41 SUTTER STREET SAN FRANCISCO 4, CALIFORNIA

Manufacturers of Krebs Cyclones, Valves and Clarkson Feeders

A Bucyrus-Erie 150-B shovel strips wasterock and dirt in a copper pit in western United States. Two more Bucyrus-Erie electric excavators and a Bucyrus-Erie rotary drill are in the background.

WHEN IT'S HIGH OUTPUT YOU WANT IT'S BUCYRUS-ERIE YOU NEED

Many copper mines are helping protect their profit margins with Bucyrus-Erie Ward Leonard electric shovels. Sustained high output is essential to economical production . . . and consistently high production is yours with these Bucyrus-Eries.

Check their design and construction advantages and you'll see why they are known as top producers in mines everywhere. Outstanding front-end design keeps a high percentage of "up-front" weight *inside* the dipper where it pays. The two-piece boom is strong yet light in weight. Crowd machinery is mounted on the revolving frame, not on the boom. Result: power swings payload, not deadweight.

When selecting stripping and loading shovels, if you consider output, cost, and long life, you will want to consider these three great Bucyrus-Erie Ward Leonard electric excavators.

128L57C

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B-293

DIFFERING national backgrounds present no problem when mining engineers and associated personnel work together, indicates an employment study in Peru undertaken recently by Cerro de Pasco Corp.

The survey showed that employes representing 28 nations are engaged in the company's nonferrous mining operations in the Peruvian Andes. Countries represented include Argentina, Australia, Austria, Belgium, Bolivia, Canada, Chile, China, Costa Rica, Denmark, France, Germany, Great Britain, Hungary, India, Italy, Netherlands, New Zealand, Norway, Paraguay, Peru, Poland, Spain, Switzerland, Union of South Africa, U. S., Uruguay, and Yugoslavia.

Peru as may be expected, has the most representatives, with the U. S., Canada, and Britain in a close race for second place.

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"UNLESS some definite and prompt action is taken" concerning foreign competition in metals and minerals "we face the extinction of an industry." C. F. Willis, consultant, thusly expressed the views of the Arizona Copper Tariff Board in a letter to the governors of the western states and members of the Western Governors Mining Advisory Council.

The major points of this stand by an important factor in the much-hassled import enigma are reported in excerpt below:

The U. S., with its high wage scale, high taxes, increasing freight rates and other factors which bring about high costs, cannot compete with the production from foreign countries with wage scales of 50¢ to $2 per day, cheap ocean transportation to eastern manufacturing centers, and the concession often given by foreign countries to U. S. capital.

Because U. S. venture capital is no longer looking to the western states, we are not only losing that which we already had but we are failing to make the progress which we should make for the future and we are placing ourselves in a position where our national security is threatened.

Increased government favoring of more and more free trade with all foreign countries and particularly an unlimited and unrestrained access for the raw materials which these countries produce is approved of by many U. S. manufacturing industries. They want to buy their raw materials at lowest possible prices regardless of where they come from and yet want and get tariff protection for the goods they manufacture.

Those who want a free and unrestrained market for foreign metals and minerals in the U. S. completely ignore the fact that the western states are largely in the same position as the foreign countries. If the western states are to have the funds with which to buy manufactured goods from the eastern U. S. the east must buy what the west produces. Moreover, the $14 to $16 a day labor of the western mines will purchase a tremendously larger amount of eastern goods than the 50¢ to $2 per day labor in many foreign countries.

During World War II the Government set up a comprehensive minerals stockpile, exploration, and production program designed to lessen our dependence on foreign supplies. The lesson was driven home during and after the war that production of minerals and metals could not be turned on or off like a spigot but that, even after making discovery, it took from one to three years to put a mine into production. Not something that our enemies would give us time to do, it was a program that had to be anticipated by years of work.

Now the program is almost complete. Having done this, we in the western states are up against an even more serious situation in protecting that which we have found and developed and gotten into production.

On copper, for instance, the Federal Government through the DMPA program made contacts with some 30 projects where copper ore was known to exist but could not be produced economically by private capital without special conditions or incentives. Each and every potential producer of copper under this program had an individual and separate contract negotiated with the Government to fit the circumstances of his particular situation. The very definite objective of each contract was to bring in more domestic copper production and have it ready in the event of war. They were all projects of doubtful economic feasibility but the program created more than 280,000 tons of increased annual copper production.

From the point of view of demonstrating domestic self-sufficiency in copper the DMPA program was highly successful. Enough new producing capacity was created so that, in the event of a national emergency, the country could take care of its own requirements without being dependent upon foreign sources. This situation, however, is of no importance to national security unless conditions are created whereby the industry can be continued in condition to do its part of the job when necessary.

Previous to this program world supply of copper was less than demand with the result that there was bidding for the limited copper available, whether it came from the U. S. or elsewhere. The prices were high and the copper mines prosperous. The increased production coming from the new mines created by the DMPA program tilted the scales with the result that world production is now in excess of world consumption. Producers of the metal are searching for buyers or accumulating surplus stocks. The natural result has been a price plunge from 46¢ per lb to 26¢ per lb. Despite this there is too much of the metal available and chances are good that, to correct the situation and get supply and demand in reasonable balance, the prices may go

even lower. Foreign mines, with their low-cost labor and water transportation can stand this competition but, even though copper prices are at bottom levels, the costs per pound of domestic production have remained or increased. There is no chance for domestic mines to adjust themselves to the situation as it would entail cutting wages and other cost cuts that would bring about tremendous complications.

Besides placing the new producers in such a position that their survival is questionable, the DMPA program has also greatly injured those that formerly produced approximately 700,000 tons of domestic copper annually. Owners of DMPA projects invested several hundred millions of dollars of their own money in getting them into production. Inasmuch as this was done as a national security measure, those who so invested have every right to expect that, even with changing economic conditions, the set-up will be changed to keep them alive and healthy. Otherwise, the original objectives of the program would be entirely lost.

To keep them producing under present conditions requires protection from foreign competition when demand is small and prices low. It is these properties which would be the first to disappear under any "survival of the fittest" program.

It is true that if the domestic price of copper goes below 24¢ per lb there would automatically be imposed a tariff of 2¢ per lb, but these figures of peril point and tariff were set many years ago. Since that time costs have increased tremendously so that the peril point, in order to be economically equivalent to its previous level, should now be 32¢ per lb and the tariff 4¢ per lb when the price of the metal drops below 32¢. Such a proposal will be introduced into Congress early in its session in January.

In view of U. S. wage standards the domestic copper producers would be justified in asking Congress for an across-the-board tariff on foreign metal regardless of the price. However, most domestic producers are willing to concede to imposing tariffs only when they are necessary for existence—when markets are limited and prices low.

We want this legislation not only because it applies to copper but because the principle and policy involved applies to many other metals and minerals. A similar situation has prevailed in lead and zinc, and producers of these metals are also seeking relief in the way of tariff protection. Legislative appeal by this industry, however, has been sidetracked by referral to the Tariff Commission for recommendation. Inasmuch as copper is already under a tariff suspension law it cannot be disposed of in the same way.

It is our opinion that lead and zinc will get favorable recommendations but that maximum aid under the laws governing tariff commission actions will be insufficient to support domestic producers and reopen the many mines that have been shut down. Therefore, they, too, may shortly be seeking legislation leading to a higher peril point and tariff.

Our job is to sell to the Administration and Congress the fact that U. S. mining, with its high wages and high standards of living cannot do business in competition with the production of foreign countries without something to equalize the differences in the cost picture.

National security demands a healthy and going domestic mining industry and this can be accomplished only by some form of protection. This protection may not be as necessary when prices are reasonable and high but as prices go down it is absolutely required for existence. The proposal we are making is not designed to put up tariff barriers against foreign metals and minerals. When fair prices prevail, there would be no excise tax.

In speaking for the Arizona Copper Tariff Board, Mr. Willis closed with a plea for unity:

"It is a proper time for all of us in the western states to work toward . . . the enactment of legislation that will put this philosophy into specific law."

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AEROMAGNETIC and geologic reconnaissance survey has been undertaken of an area comprising a million acres in south central Maine, according to state geologist J. R. Rand. A Varian nuclear precession magnetometer is being used in the aeromagnetic survey which is covering three widely spaced groups of long flight lines with fill-in of anomalous areas. Compilation of all data is expected to be completed for release late in February by the Maine Geological Survey, a division of the Department of Economic Development.

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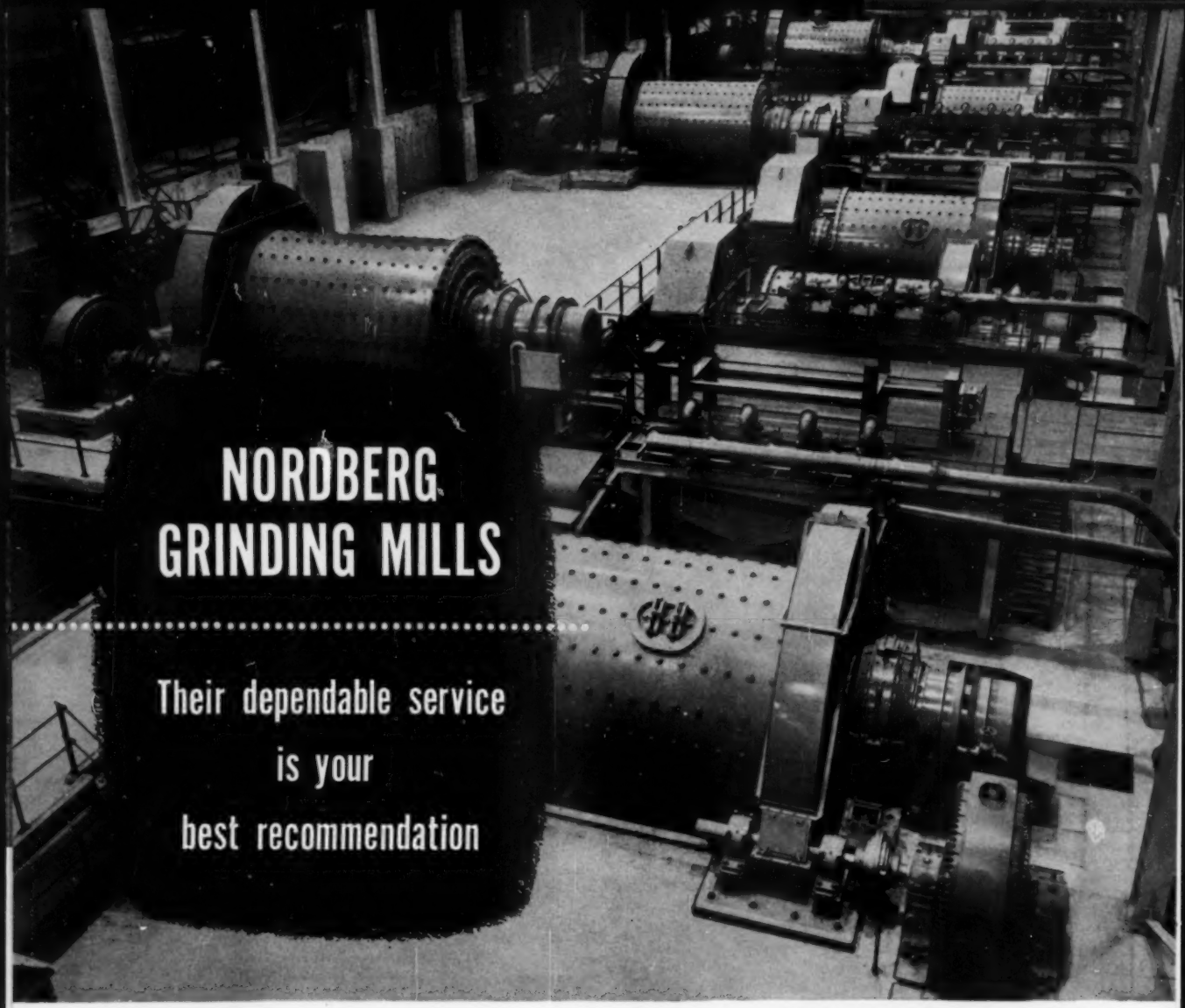
FOR the first time since 1948 the mineral production of Canada will show a setback when final reports are tallied. Even by mid-1957, production of copper, lead, zinc, gold, and silver had fallen below the levels of the previous year.

Producers, for the most part, will probably tend to hold back on some expansions this year for reasons of already excess capacity in terms of the present market and the tighter squeeze on profits.

Increasing criticism is being levelled by Canadians at U. S. proposals for higher tariff protection against imported base metals. One often-voiced claim is that Canada had complied with requests for stepped-up production of these commodities and their diversion to the U. S. from other markets in past years, but that this had been forgotten when the market suffered its recent reversals.



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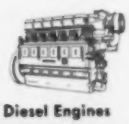

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MINING engineering

DRIFT

Abstract, Preprint, and Programs

AT the meeting of the Board of Directors of the Society of Mining Engineers in Tampa last Fall we were directed to work out a satisfactory Preprint Program for the papers to be presented at the AIME Annual Meeting in New York in February 1958. Taking into account the comments and suggestions of the members that have come to our attention we have worked out a plan. We believe this plan will accomplish the following aims:

1) It will make copies of convention papers available to *all* members of the Society, those who are not able to attend the Annual Meeting as well as those who can arrange their affairs to be there.

2) It will allow each member to decide for himself which papers he wants and which papers he does not want.

3) It will make copies of papers immediately available to the members. There will be no delay while waiting for publication in MINING ENGINEERING and the annual Transactions Volume.

4) It will make available papers that appeal to only a small proportion of the membership. In the past space limitation and the recommendations of the various Publications Committees have made it impossible to publish some papers that might be extremely interesting to a small segment of the Society's membership.

5) It will accomplish these aims at a cost well within financial capabilities of the Society. It is believed that in time this plan will be almost entirely self-supporting.

This is how the plan works: As the Annual Meeting Program reaches final form, each paper is given an identifying number. Every author has been asked to supply a brief (not over 250 words) abstract of his paper. This abstract, together with the number of the paper, will be published in a special section of a Pre-Meeting issue of MINING ENGINEERING. This year the January issue is this special issue. In the future, with the cooperation of all concerned, it may be possible to publish this preview in an earlier issue. Abstracts are presented in this special section in the order, by Divisions, in which the papers will be given in February. With this before him, each member can decide, well in advance, which sessions he will want to attend and which papers he wants to hear.

The special section of this issue of MINING ENGINEERING that contains the abstracts of the papers to be presented in February has been specially designed to replace the *Abstract Booklet* of other years. It contains, in addition to the abstracts, the complete program of sessions sponsored by the Divisions of the Society of Mining Engineers. It has been printed on special paper to allow members to make marginal notes. Its format will permit it to be removed from the magazine and folded to convenient pocket size. Members who plan to attend the meeting are urged to bring this *abstract booklet* along. There will be only enough extra copies available to take care of non-members who register for the meeting and AIME members of the other constituent societies who request a copy. Periodically a list of current preprints

(Continued on page 38)

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Journal of Metals—monthly

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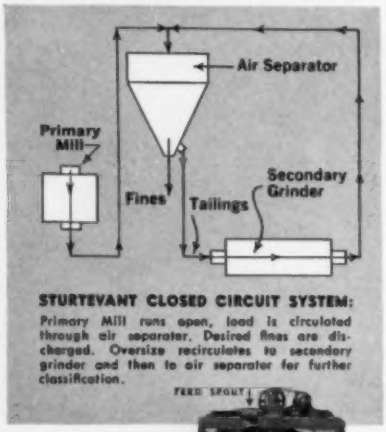

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Drift

(Continued from page 37)

still available will be published in MINING ENGINEERING.

Every author has been asked to supply us with an advance copy of his paper. As these come in to Society Headquarters they are reproduced, with little or no editing, including all drawings and photographs. This presupposes that drawings and illustrations are of a quality that can be reproduced without expensive redrawing or art work. A supply of these Preprints will be available at a central location at the meeting in the Statler Hotel. An additional supply will be kept on file at Society Headquarters until December 31 of the year in which the meeting is held. At this time all remaining copies, if there are any, will be destroyed to make room for the next set of Preprints.

Distribution of Preprints will follow a definite pattern. With his dues bill, each member of the Society of Mining Engineers will receive a booklet of five (5) coupons in partial satisfaction of his annual dues. This year these coupons will expire on Dec. 31, 1958. Each coupon is exchangeable for *one* Preprint without any further charge. Each coupon also serves as a mailing label. There is a space in the upper right hand corner where the member will fill in the number of the Preprint for which he wants to exchange that particular coupon. In the space provided for that purpose he will fill in his name and correct mailing address. It only remains for him to place his coupons in an envelope and mail them to *Preprints, Society of Mining Engineers of AIME, 29 W. 39 St., New York 18, N. Y.* To pick up Preprints at the meeting itself, he need only fill in the coupon and present it at the SME Preprint Distribution Desk at the Statler. Each SME Member who attends the Annual Meeting in New York will receive a second book of five (5) coupons when he registers. Nonmembers who indicate an interest in SME when they register will also receive a book of five (5) similar coupons. These are subject to the same limitations as the coupons mailed with the dues bills.

For those who want more Preprint copies than provided for by the above procedure, booklets of ten (10) coupons each will be available for sale—by mail and at the Convention. The price will be $5.00 to members of AIME and $10.00 to nonmembers. These coupons are similar to those described above, except that they will be valid indefinitely for current preprints.

In designing this Preprint Plan we have tried to work out a system that will render maximum service to *all* the members of the Society of Mining Engineers of AIME. As with every new operation a number of *bugs* will show up in actual practice that were not evident on the original flow scheme. In accordance with good milling practice we look at the February 1958 Annual Meeting in New York as a pilot plant operation. The flow sheet will be altered to eliminate any bugs that show up there. As experience is gained, it may be possible to extend this service to all meetings in which the Society takes part. Time and the comments of the members will tell us how well we have designed.

John Cameron Fox

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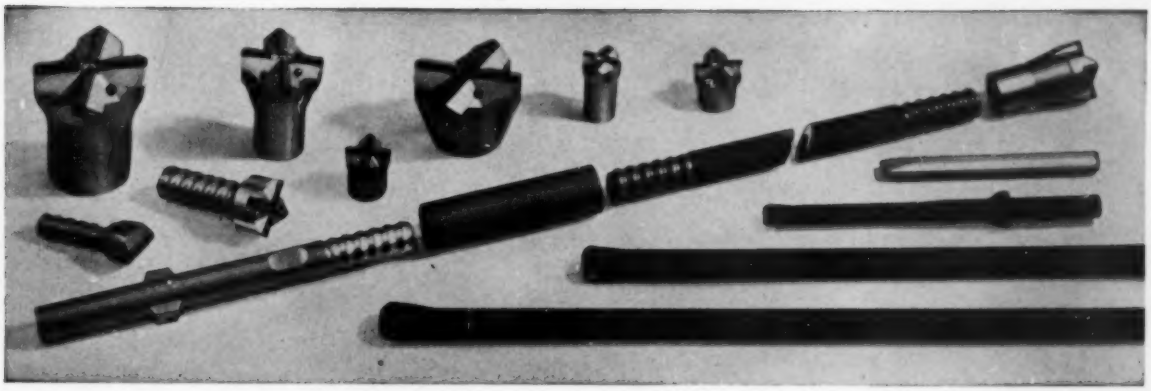

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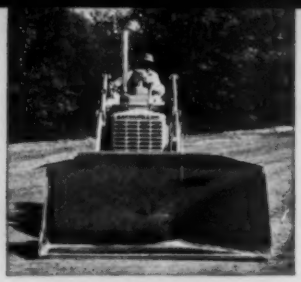
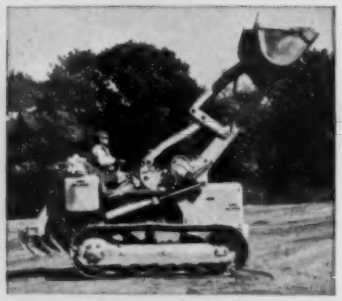
Here  *comes...*

the TRAXCAVATOR'S  *new...*

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Abstracts

Society of Mining Engineers of AIME

AIME Annual Meeting, February 16 to 20, 1958

The Abstracts are arranged alphabetically by Divisions and chronologically by sessions. For full information on the SME *Abstract and Preprint Program*, see page 37. Deadline for receipt of abstracts at SME headquarters was November 25. Tear this section out of the magazine and bring it to the Annual Meeting with you, since no other abstract booklet will be distributed.

Papers for which preprints are available are listed by number on page 113. These may be obtained only by mailing in SME coupon properly filled out.

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(These sessions are joint ones with the SME Geology Subdivision; see under Geology for abstracts.)

ABSTRACTS

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Coal Division

Bump Symposium

9:30 am Monday, February 17 Penn Top South

G. R. Spindler and E. Minor Pace, *Chairmen*

Activity of the Bureau of Mines in Bump Investigation and Research by *Edward Thomas*—For ten years after the retirement of the late George S. Rice, USBM did little toward investigation and research in the problem of bump research and investigation. This was largely because a drop in the production of bump areas resulted in a lowering of the percentage of bump injuries in coal mines. However, with a trend toward an increase in production and a consequent increase in accidents in 1951, a statistical project was initiated in coal mines which resulted in *Bulletin 535* in 1954. This is an analysis of 117 occurrences of bumps in coal mines and shows that 67.6 pct of such occurrences are associated with pillar-line points. Slabbing, splitting pillars, development in abutment zones, and other unfavorable mining practices are indicated as contributory or basic primary causes of bumps. The greatest need at the present is the ability to compromise with known principles in a way that areas that have been committed to unfavorable mining practices started in the past can be mined with a maximum of safety.

Much work remains to be done from the standpoints of tying geological conditions to occurrences; instrumenting pillars for loading and gathering data on strength of coals, bottom rocks, and roof rocks to make the prediction of bumps more certain; and in the analysis and prediction of *regional* bumps. **5817A14.**

Ground Stress Investigations in Canadian Coal Mines by *A. Brown*—Investigations into the phenomena of rock stress in underground mine workings are being conducted by the Dept. of Mines and Technical Survey, Ottawa, Canada, for the purpose of learning additional facts about the behavior of ground under stress. It is hoped that a more fundamental knowledge of the factors involved may prove beneficial to the mining industry and assist in the optimum recovery of Canadian mineral resources.

For the conduct of such studies the Department has assembled a small group of mining engineers and physicists who are aided on specific problems by Departmental geologists. Cooperative studies are also promoted in certain Canadian universities and provincial research groups. Considerable importance is placed on observations bumps. Over the past years a considerable amount of theory applying to stress about mine openings has been developed. Also a great deal of experience has been accumulated under conditions that produce bumps. This paper presents a critical examination of mining practices and conditions which in the light of theory and experience can result in bumps; also in the light of this theory and experience mining practices designed to prevent the occurrence of bumps are suggested. A great many opinions are held by mining personnel with regard to bumps which are incorrect. Some of these are also examined in the light of theory and experience in an attempt to promote correct conceptions as to the cause of bumps. **5817A19.**

Coal Preparation

2:30 pm Monday, February 17 Penn Top North

Paul L. Richards and Harry Washburn, *Chairmen*

Cleaning of Fine Coals by Convertol Process by *S. C. Sun and W. L. McMorris, III*—The purpose of this investigation was twofold. First, the relative effectiveness of various oils and hydrocarbons was tested for the operation of the convertol process. Second, the behavior of coal pulps under various operational conditions, such as concentration of oils, pulp density, speed and time of phase inverter, temperature of coal slurry, and conditioning and retention times, was also determined. Three fine coal samples were used in this investigation. **5817P15.**

Fluidized Thermal Drying of Fine Coal

9:00 am Tuesday, February 18 Penn Top North

D. A. Dahlstrom and F. M. Stephens, *Chairmen*

Technical Session

9:00 am Wednesday, February 19 Penn Top North

E. M. Spokes and J. Allen Brookes, *Chairmen*

Meeting the Challenge of Mining in 30° Pitching Coal Seams by

within the mine workings, supplemented by laboratory based studies leading to the development of dependable field apparatus. Laboratory investigations are also conducted into the physical properties of rocks and minerals.

Field investigations are being conducted with a variety of dynamometer and convergence measuring apparatus in the open workings and devices for observing stress changes within the solid are being developed. Some of these latter have had fairly extensive field trials. The laboratory investigations into rock properties were initially based on short period uniaxial compression testing of unconfined specimens and a considerable body of data has been secured on Canadian and some foreign mine rocks. More recently, apparatus has been devised and is now in routine use for observing the effects of time-strain. Currently, equipment is being constructed for triaxial testing. 5817A15.

The Occurrence of Mountain Bumps at the Sunnyside, Utah, Mines of Kaiser Steel Corp. by *John Peperakis*—Mountain bumps of severe intensity have posed serious problems since early mining days at the Sunnyside, Utah, coal mines of the Kaiser Steel Corp. Mining operations dating back 60 years have left large worked out and partially worked out areas around which present day mining operations are centered. The combination of old worked out areas, deep cover, thick sandstone beds, rugged terrain where appreciable changes in cover occur over relatively short horizontal spans, a fragile roof, and faulting set up conditions conducive to mountain bumps. A number of major bumps are described in detail. Present day development and steps taken to reduce the bump hazard are given in detail. 5817A16.

Progress in the Control of Mountain Bumps in the Pocahontas No. 4 Seam by *Woods G. Talman and John L. Schroder, Jr.*—The first significant step towards controlling mountain bumps in the Pocahontas No. 4 seam in Gary, W. Va., District was the design and installation of a thin pillar mining system incorporating a minimum of secondary development. This system had its limitations because as pillar extraction retreated to an inevitable loaded block, the system no longer was applicable. Therefore, it was decided to experiment with auger drilling to accomplish a controlled release of the stored energy in the vulnerable block. As a result of the drilling experience to date we have established a set of *thumb rules* which guide in the planning for probing on stress relieving vulnerable blocks. Exhibits 4 through 8 show one of our recent drilling and mining sequence plans for stress relieving a large block in Gary No. 2 Mine. During the course of the job a heavy bump occurred from which we gained additional knowledge and contributed to our thumb rules. Since 1953 several improvements in the drilling program have resulted from modifying the equipment and procedures. A new crawler mounted auger custom-built to our specifications was received in August 1957. Other improvements include an auger protective device, auger sections with closer spaced ribbons, auger section connecting bolts, rapid bit change-out feature on cutter head, and optimum drilling rate. Our progress in the control of mountain bumps has been made possible primarily by a trial and error approach to a safe and workable drilling plan, careful study and thorough analysis of all bumps, and consultations with outside roof control specialists. 5817A17.

Coal Mine Bumps Can Be Eliminated by *H. E. Mauck*—Bumping can be eliminated if certain basic and fundamental factors are used in the planning of the mine. Certain geological and mining conditions pertaining to any given seam of coal must become a part of the plans of mining. From factor characteristic to a specific seam and conditions it is possible to eliminate bumping.

There are two types of bumps—*pressure* and *shock*. Pressure bumps occur under great loading factors and shock bumps occur during large strata ruptures. Bumps occur in coal mines throughout the world and usually under conditions of heavy cover, strong immediate strata above the seam, tough nonheaving floor, mountainous terrain, steeply pitching beds, and nearness of faults and other geologic structures. To eliminate coal mine bumps much study must be given to the seam and its adjacent strata.

The factors which should be taken into consideration in developing a mine plan are as follows: 1) limit number of entries; 2) maximum width of barrier pillars; 3) pillar areas should not be created on both sides of a main entry system; 4) pillar mining should be accomplished by withdrawing from boundary, either natural or arbitrary; 5) all pillars should be uniform in size and shape; 6) pillars, both chain and barrier, should be of maximum dimension; and 7) pillars should be worked open-ended in full extraction work. 5817A18.

Causes and Control of Coal Mine Bumps by *Charles T. Holland*—Bumps occur in coal mines when working under heavy, strong cover. Unquestionably, ground stress is the immediate cause of the

Albert M. Keenan and Andrew Allan—The Thompson Creek Coal and Coke Corp. in Colorado is producing a high grade medium volatile coking coal from seams having a pitch of 30°. The coal is presently being mined from two separate mines in different seams having thicknesses of 84 and 108 in., respectively, and the present system includes the use of shaker conveyors along the strike of the seam. The coal is blocked out into panels 400 ft up the pitch and 300 ft in length. This system has contributed greater safety, with improved control of the mining operations.

Roof control has been, and continues to be, a great challenge in this operation. It is being successfully controlled by good engineering which affords properly maintained mining sequences. The upper seam of coal in one of the mines having been previously extracted offers many problems to successful mining of the lower seam.

The degree of inclination of the seam (30°) offers a great problem to secondary haulage accomplished by gravity. Further, the pitch is too great for a system employing mobile mining machines, and not steep enough for shrink stoppage or induced caving methods. The property does however offer a distinct possibility for longwall mining which is being planned for lower depths. 5819A14.

The Application of Industrial Engineering in Coal Mining by *Charles W. Rountree, Jr.*—This paper deals with the application of industrial engineering principles and techniques in the coal mining industry. The use of industrial engineering in coal mining has been viewed by many as impractical and almost impossible, since coal mining is considered a highly variable industry; however, it has been conceded that industrial engineering is applicable to the manufacturing industry. Tools of production and cost control which have proven successful in manufacturing will be discussed in this paper, along with their utilization by the coal industry to increase productivity and decrease costs. Among the tools to be discussed are production standards, time study analyses, standard cost budgets, cost variance analyses, and methods analyses. 5819A15.

Technical Session

2:00 pm Wednesday, February 19 Penn Top North

Jesse F. Core and C. L. Sarff, *Chairmen*

Benefits Which Derive From the Use of A-C Power Underground by *C. S. Conrad*—The subject is presented following an outline which includes: 1) safety considerations—subdivided to consider the problems of mine fire, dust ignition, gas ignition, shock to personnel and illumination; 2) machine performance and production continuity; 3) maintenance costs; 4) equipment investment costs; and 5) power costs. Each feature is discussed generally with some effort made to avoid technical terminology. The feature *Safety Considerations* is given most time. The remaining features are then generalized, since the technical ground work is covered under one. 5818P5.

Continuous Coke Production on a Water-Cooled Grate Stoker by *R. J. Grace and Joseph D. Doherty*—The purpose of this paper is to present the results of a limited research program devoted to a study of the adaptation of a water-cooled grate stoker, which was used in conjunction with a conventional steam boiler for the production of coke suitable for certain chemical or metallurgical processes. The overall thermal efficiency of the stoker-boiler combination is discussed, as also are some economic factors pertinent to commercial application of the process. 5819P6.

Pioneering Carrier Current Communication and Control in Mines and Mills by *W. P. Place*—This paper describes the development of Trolleyphone. While carrier current had been used by the telephone and power companies, applying carrier current to moving vehicles such as coal mine locomotives and traveling cranes to provide communication presented a number of new problems. Chief among these are the high noise level of the dc power distribution system, the great variation in signal strength, the heat, moisture, and mechanical vibration with which the equipment must live. How these various problems were met and overcome and how the knowledge gained is later used to make remote control equipment available is set forth. 5819P7.

Technical Session

9:00 am Thursday, February 20 Penn Top North

J. B. Benson and C. M. Donahue, *Chairmen*

Safety Features in the Design and Development of Ireland Mine by *G. W. McCaa*—The Ireland Mine is a new deep mine of the Hanna Coal Co., division of Pittsburgh Consolidation Coal Co., in Marshall County, W. Va. Construction work was started in 1956 and will be completed in 1958.

Safety has been given primary consideration in the planning of both the surface and the underground operations. The mine is in Pittsburgh seam and the coal is being mined with continuous miners, both the ripping and boring types. The continuous miners have been equipped with roof bolting units and are working under draw slate which is being safely supported with roof bolts and planks. The main haulage roads and air courses are being permanently protected with roof bolts and gunite.

A modern haulage system is under construction using large mine cars and large locomotives. All face equipment uses ac power with groundtrip protection. The cover over the seam will exceed 1000 ft. A panel and block system is projected for the operation of the continuous mining machines under this heavy cover. Improved methods were used in sinking the shafts and slopes mechanically. **5820A19.**

Technical Session

2:00 pm Thursday, February 20 Penn Top North

Henry J. Hager and James D. Reilly, *Chairmen*

Roof Bolting in Kentucky Coal Mines by *George K. Martin*—An explanation of roof bolting in Kentucky mines covers the origin, necessity, and successful use of roof bolting, touching on sizes, types, methods of installation, recovery, etc. Also a comparative study is made of roof bolting vs conventional timbering for tonnage, fatalities, and casualties. The information presented in this paper was obtained from operating mines in Kentucky, USBM, Kentucky Dept. of Mines and Minerals, and extensive research on part of the author. **5820P19.**

Handling Air from Conventional Coal Dryers by *M. I. Dorfan and Raymond Mancha*—The authors proceed with an orderly description of so-called *conventional* coal dryers and their various operating cycles. Included in the description are such units as the McNally Pittsburgh Pulso dryer, the Link-Belt Multi-Louvre dryer, Combustion Engineering's Raymond Flash dryer, and the Dorrco FluoSolids system for fine coal drying. Appropriate illustrations accompany the script. The general accompanying ventilation problems are next discussed, dealing particularly with the waste economics of the problem accompanying inadequate salvage. Next, the Joy Microdyne dust collector is described in technical detail, thereby explaining the successful operation of this unit under widely varying conditions. **5820P20.**

Council of Economics of AIME

Mineral Economics Session

9:00 am Monday, February 18 Georgian Room

L. C. Raymond and Evan Just, *Chairmen*

Copper Market Prospects by *Joseph Zimmerman*—The prospects for the copper market in 1958 will entail a discussion of the following: 1) The supply-demand situation from a domestic and a world point of view. 2) The role of the Government in the copper industry. 3) An analysis of those factors that have a bearing on the domestic and foreign price of copper such as: a) mining companies' policies with respect to production, b) production costs as a factor in determining the selling price of copper, c) methods of marketing and pricing copper, and d) psychological influences of shortages, or surpluses, or fears of mounting or declining prices and their market consequences. There is a need for a promotional campaign to stimulate the use of copper and to open new channels of consumption. **5817P23.**

Economic Evaluation of an Industrial Mineral Project by *J. E. Castle*—The necessary steps to make a sound economic evaluation of a new industrial mineral project are enumerated. Primary importance is attached to market survey and analysis. After market it increase in direct proportion to depth? Will there be a sudden catastrophic inflow of water at any time? What will be the effect of drifts extending outside the cone of depression? Answers to these questions must take into consideration an understanding of the local geology and of some principles of ground water behavior. A program calling for an appraisal of water-level measurements and of all ground water conditions prior to mining and during various stages of development should supply adequate information to anticipate difficulties and to allow for corrective measures. **5817A20.**

Hydrologic Factors That Affect Water Control in the Zinc-Lead Mines of Southwestern Wisconsin, by *Charles L. R. Holt, Jr.*—The Sn-Pb mines in southwestern Wisconsin are being operated under wet conditions with some mines producing water at rates of 3000 to 5000 gpm. A study is being made of the factors involved in the movement of ground water toward a mine area with the hope that the information will lead to methods of water control and reductions in mining costs.

The combined pumpage from two mines has formed a pronounced cone of depression which, in 1957, had an areal extent of 12 sq miles. The cone of depression reaches essential stability in areas where advancement of the mine drifts has ceased. In the areas of active drift advancement, the hydraulic gradient is very steep and the cone constantly expands.

Water enters the mines through solutionally enlarged joints, fractures, and bedding planes, and through open drill holes in the limestone aquifer—the Zn-Pb bearing strata. The largest flows of water are encountered in synclinal structures and in highly fractured ore zones. The drifts are dry in sections lacking enlarged joints or fractures. Zones of lateral flow are found at a number of stratigraphic contacts.

Piezometric maps and quantitative data show that, where the head of water in the limestone aquifer is less than in the overlying Maquoketa shale and in the underlying St. Peter sandstone, the ground water in those formations will leak into the limestone aquifer. This vertical leakage contributes an important part of the water entering the mines. **5817A21.**

Minerals for Newer Ceramic Applications by *Edward J. Smoke and John H. Koenig*—Ceramic products are made of inorganic nonmetallic minerals and are usually subjected to high temperature during fabrication. Clays are by far the most widely used minerals in the ceramic industry. However, many minerals relatively new in the ceramic field are playing very important roles. Talc, wollastonite, alumina, petalite, zircon, zirconia, etc., are being used to make refractories, low and high frequency electrical insulators, heat and sound insulators, structural materials, etc. These minerals will be discussed in light of their structure, purity, etc., for ceramic applications. **5817A22.**

General Industrial Minerals

(Joint Session with Minerals Beneficiation Division)

2:00 pm Monday, February 17 Sky Top Room

G. W. Josephson and Norman Sather, *Chairmen*

New Concepts of Bulk Solids Lifting by Bucket Elevator by *Calvin R. Davis*—This paper deals with many of the important advancements in application, design, and manufacture of bucket elevators and bucket elevator components.

Beginning with the two basic elevator types—centrifugal discharge and continuous—a foundation is built for principal avenues of elevator application which have led to today's elevator improvements. The pioneering of bucket style, independent of the carrying medium, as a means of determining elevator selection, is one of the avenues of elevator application discussed.

The approach to abrasion problems involving chain and belting as the primary lifting media correlates mineral hardness as a criteria for dependable elevator life. The effct of chain loading in centrifugal elevators with capacities over 200 is related to fatigue strength in the design and manufacture of chain. Selection of elevator belting from the standpoint of resistance to pull-through, bucket attachment, covers, and splice efficiency, play an important part in adequate belting applications. And new effectiveness in the use of elevator components such as self-aligning bearings, gravity takeups, segmental rim sprockets and traction wheels, and casing enclosures which lower maintenance costs, are also discussed.

Touched upon briefly is the special consideration that should be given to materials involving heat and corrosion, or which are nonfree-flowing. **5817P16.**

survey indicates the existence of a favorable market situation, production costs are then calculated. The most common sources of errors in estimation of production costs are listed and discussed. The next important steps are the calculation of capital requirements, both working and fixed capital; the estimation of manufacturing costs; and the calculations of profits. Finally a breakdown chart is constructed from the assembled data. **5817P24.**

Mineral Economics Session

9:00 am Wednesday, February 19 Ivy Suite

J. L. Kimberley and Alvin Knoerr, *Chairmen*

An Exciting Future Ahead with Lead—An Industry Program by *Robert Lindley Ziegfeld*—Because lead has been around a long time, most people think they know all about it, but this is far from true. Statistically, some two-thirds of its usage arises from twentieth century developments. The automotive industry has been heavily dependent on lead and now our newest industry—the atomic industry— is finding the properties of lead indispensable. Now lead applications are being found in missiles and movie screens, plastics and porcelain enamels, electronics and expansion joints.

The Lead Industries Assn. is employing a variety of tools to take advantage of these exciting new developments as well as to hold and expand existing markets. Research, advertising, and technical promotion are all a part of the plan. A framework has been set up for greatly expanded research in both the applied and basic fields and a study of the industry's research needs was completed for the Association in 1957. Advertising and technical promotion are being used to develop markets in the ceramics, paint, building and chemical construction, radiation shielding, solder and other specific fields, as well as to disseminate technical information and invite cooperative effort with other industries to develop new uses. **5819A8.**

Free World Demand and Supply of Chrome Ore by *J. M. Warde*—This paper discusses the Free World demand, supply, and price history of chrome ore with particular reference to U. S. requirements. By 1970, it is anticipated that Free World consumption of chrome ore for metallurgical, refractories, and chemical use will be more than double the apparent consumption in 1953. Turkey, Southern Rhodesia, and the Union of South Africa are expected to continue as leading world sources. A decline in output of refractory grade ore from the Philippines and Cuba, currently the leading U. S. sources of this type of ore, is expected during this period. The increased use of lower grade ores for metallurgical consumption will continue as sources of high grade lump ores are depleted. **5819A5.**

Recent Developments in the Allowance for Percentage Depletion by *Frank H. Madison*—A discussion of the many problems entering into the calculation of *gross income* and *net income from the property* in the light of the regulations (111 and 118 under the 1939 code and the new regulations covering the Revenue Act of 1954) and of several court decisions upsetting these regulations. **5819A7.**

Industrial Minerals Division

Mine Hydrology

9:30 am Monday, February 17 Washington Room

W. T. Stuart and J. B. Graham, *Chairmen*

Some Notes on the Principles of Mine Hydrology by *Harry E. LeGrand*—The development of a mine below the water table disturbs the natural ground water regimen, causing a convergence in the flow of water from a surrounding area. The mine becomes the apex of a depressed cone in the water table. The behavior of the cone of water-level depression, as the mine enlarges, is governed by geologic conditions. In spite of complex geology and apparent uniqueness of individual mines, adherence to some concepts of ground water used by hydrologists in the study of the action of wells should be helpful to mine operators. A question of importance concerns the rate of pumping at various levels in order to keep the mine dry. Will the rate of pumping be greater with depth? Will

Removal of Heat in Cement Grinding by *J. Richard Tonry*—Heat produced in the grinding of cement may be removed, and the temperature of the final product lowered by various procedures. These include water cooling of mills, water injection into mills, air cooling of the separator, and a proposed method of cooling the mill charge. Typical results for these methods are given and calculations are shown for the proposed method, together with tables and illustrations. **5817P17.**

A Critical Study of Thickening by *A. M. Gaudin, M. C. Fuerstenau, and S. R. Mitchell*—Studies on the batch-settling behavior of clay pulps show that traditional charting of results conceals information. A plot of settling velocity vs elapsed settling time is preferable. It shows the dependence of settling on settling depth and container diameter which were unsuspected variables. It is also useful to analyze the effect of known variables, such as composition and quantity of flocculant, temperature, and pulp dilution. **5817P18.**

The Application of Horizontal-Type Filters to the Metallurgical Industries by *William F. White*—While horizontal filters have been used in the metallurgical industries for a number of years, recent developments and improvements have greatly increased the range of application and have led to better performance and greater economies.

A discussion will be presented covering design and operating characteristics of the various types of horizontal filters, their proper application and the specific advantages of each design. Operating and performance data will be presented on existing installations in a few selected processes. **5817P20.**

Geology of Titanium

(Joint Session with Geology Subdivision and Society of Economic Geologists)

9:00 am Tuesday, February 18 Georgian Room

Wm. H. Callaghan (Geol)

and Meredith Johnson (SEG), *Chairmen*

For Abstracts, see under Geology Subdivision, page 53.

Uranium, Thorium, and Beryllium

9:00 am Wednesday, February 19 Penn Top South

Pauline Moyd, *Chairman*

New Trends in Uranium Geology by *Donald L. Everhart*— During the past ten years, a large world-wide literature on the subject of uranium geology, in all of its aspects, has been built up. In general, publications on uranium geology to date have fallen into the following four categories: 1) discriptions of hundreds of uranium ore deposits or occurrences throughout the world, 2) studies of the geochemical nature (including mineralogy) and behavior of uranium, 3) a few attempts at the classification of uranium ore deposits on the basis of a variety of associated geologic features; and 4) some speculation as to the origin and geologic controls of uranium ore deposits—both generally and in specific districts or regions.

At the current stage of the science, there is a continuing need to perfect the geologists' understanding of all possible and known *processes* of uranium concentration and deposition as the only basis for a complete and reliable appraisal of the world's future uranium resources. **5819A16.**

Geology of the Uranium Deposits in the Ambrosia Lake-Jackpile Area, New Mexico by *Lowell S. Hilpert and Allen F. Corey*—Eighty percent of the uranium reserves of the Colorado Plateau are in northwestern New Mexico, according to figures published by the AEC. Nearly all these reserves are in a relatively small area in the southeastern part of the San Juan Basin, referred to here as the Ambrosia Lake-Jackpile area. In this area most of the uranium deposits are in sandstone units of the Morrison formation of Jurassic age, although a relatively small number of deposits occur in the Todilto limestone, also of Jurassic age.

The deposits in the Morrison formation contain disseminated uraniferous carbonaceous material. Coffinite probably is the dominant primary uranium mineral. Descriptions of the deposits are given, including occurrence, size, and shape.

Uranite is the dominant primary mineral in deposits in the

Todilto limestone, and the occurrence, size, and shape of the ore bodies are covered. The geological history of the uranium is also covered. 5819A17.

Commercial Thorium Ores by *Howard E. Kremers*—Although more than 100 thorium-rare earth minerals are known, only a few have any commercial significance. Monazite, thorite, bastnasite, and some exotic thorium-rare earth ores are reviewed. Commercial interest is presently centered on monazite from the Union of South Africa and thorite from this country. 5819A18.

Beryllium Raw Material as It Affects the Growth of the Industry by *Stanley A. Feitler*—Reliance on hand-sorted beryl from pegmatite dikes imposes a relatively low ceiling for expansion in the industry. The limited safe annual supply from this source, although well above present consumption, is a deterrent to research aimed at development of new large volume applications for beryllium. This paper discusses the factors involved and the possibility of increasing the raw material potential by expanding the investigation of nonberyl sources of beryllium. 5819A19.

General Industrial Minerals

2:00 pm Wednesday, February 19 Penn Top South

Ray Shrode, *Chairman*

Underground Movement and Subsidence over the United States Potash Co. Mine, Div. of the U. S. Borax & Chemical Corp. by *Earl H. Miller, and Francis L. Pierson*—With the aid of slides, a talk will be given on the observed measurements and data on subsidence, both underground and on the surface, of the United States Potash Co. mine. This mine is approximately 1000 ft below the surface and is immediately overlain by a salt section of approximately 500 ft thickness. The company, through experience, has developed a method by which some 90 pct extraction of potash ore can be maintained with little or no use of artificial supports.

In addition to submitting recorded data, several of the major factors affecting the operation will be discussed. Further, effects and influence on the surface due to subsidence will be shown, together with two methods of collecting and tabulating data for study. The fact that the highly soluble salt is overlain by water-bearing strata and separated from it by an impervious anhydrite bed makes strata control in subsidence imperative to the safety of personnel and to the mine itself. 5819P9.

Boron—Its Past, Present and Future by *D. S. Dinsmoor and F. J. Weishaupt*—Boron, Comprising about 0.0001 pct of the earth's crust, is a comparatively abundant element; however, it is not known to occur free in nature and of the many minerals containing boron, only the borates are important.

Boron, as borax, has been used by man, for centuries. Less than a 100 years ago, borax was a high-priced commodity used only in small amounts and in limited applications. Today, it is an important industrial material used in great quantity for a host of purposes. The price is low and stable and the known ore reserves very large. Of the world's supply, 95 pct is produced from two locations in southastern California less than 100 miles apart.

Borax has acquired a wide use as an industrial material but boron may be only in its infancy. The recent realization that elemental boron and some of its compounds may have practical application has intensified research. In some instances, it has already borne fruit, in others extremely difficult problems remain yet to be solved. In spite of the herculean problems, however, researchers have high hopes for success. 5819P10.

Minerals Beneficiation Division

Crushing and Grinding

9:30 am Monday, February 17 Penn Top South

Bunting Crocker and Frank Windolph, *Chairmen*

Ball Mill Performance at Supercritical Speeds by *R. T. Hukki*—The purpose of the paper is to clarify the basic relationship between the principal variables of tumbling charge, friction, and mill speed in a laboratory size mill operated under idealized conditions through a speed range never tested before. The obtained mill characteristics show the centrifuging threshold values for

Concentration

2:30 pm Monday, February 17 Pen Top South

S. E. Erickson and R. H. Lowe, *Chairmen*

The relation of Magnetic Susceptibility of Composition in Minerals of the Wolframite Group and in Sphalerite by *Ernest M. Spokes and David R. Mitchell*—Published values of magnetic properties of minerals are available for barely 70 species; wide variations in the susceptibility of different specimens of the same mineral have not been explained satisfactorily. In order to provide some of this information, the National Science Foundation made a grant to The Pennsylvania State University for a study of the fundamental relationships of magnetism and composition in minerals.

A Gouy-type balance was used to determine susceptibilities. Glass sample tubes of 6-mm bore were calibrated with distilled water. Specimens were crushed to −48 mesh and cleaned by magnetic and gravitational methods; they were then reduced to −270 mesh. Determinations were made at 10,000, 15,000, 19,000, and 21,000 oersteds.

Susceptibility in the wolframite group was found to be lowest in high-iron members because susceptibility of the ferrous ion is lower than that of the manganese ion. The spread in susceptibility across the series is not enough to cause significant differences in the ease of magnetic concentration. Susceptibility appeared to vary inversely as the square root of the iron content, which varied from 0.34 to 17.70 pct.

Easier magnetic concentration of ferberites reported by preparation plants is attributed to the effect of intimately associated magnetite.

Sphalerites displayed the ferromagnetic characteristic of dependence of the susceptibility upon the field strength. Highest values were observed at the 10,000-oersted field, with consistent decreases to the 21,000-oersted strength. Susceptibility of the specimens at 10,000 oersteds was found to vary directly as the square root of the iron content. 5817P9.

The Dual Process at Inspiration by *C. D. Kettering and K. L. Power*—Inspiration's revised flowsheet for the treatment of mixed oxide-sulfide copper ores is described. Reasons for the change in flowsheet are given as are the results currently being obtained. 5817P10.

Trends in Uranium Milling by *R. H. Kennedy*—This paper gives a survey of new uranium treatment plants and a summary of the treatment methods now in use together with some thoughts on the trend for future plants. 5817P11.

Collector Mixtures and Collector Emulsions in Sulfide Mineral Flotation by *Arvid Anderson*—This paper describes process development and operating results obtained by the use of collector mixtures and collector frother emulsions in the flotation of chalcopyrite and pyrite ores. 5817P12.

Theory of Concentration Processes

10:00 am Tuesday, February 18 Sky Top Room

E. W. Giesecke and M. E. Wadsworth, *Chairmen*

Mechanism of Flocculent Adsorption of Clay Minerals by *M. E. Wadsworth and A. S. Peck*—Adsorption isotherms were obtained for the adsorption for two high molecular weight polyelectrolytes on acid washed kaolinite. The adsorption data were obtained by measuring the solution depletion of polyelectrolyte which was complexed with a colloid of opposite charge; the concentration of which could be measured by light scattering techniques. The adsorption isotherms obtained are typical of type one Langmuir isotherms. Adsorption potentials measured from the equilibrium isotherms obtained indicate a potential corresponding to hydrogen bonding. The results obtained also indicate that the surface of kaolinite contains ion exchange positions which of themselves are sensitive to changes in pH. 5818A14.

Solubility of Some Metal Ethylxanthates by *P. J. van Heteren and P. L. de Bruyn*—Conductometric and potentiometric methods have been used to determine the solubility of various metal ethylxanthates. The solubilities of the base metal salts were observed to increase in the following order:

$$Ag^{+}, Fe^{+++}, Cu^{++}, Pb^{++}, Zn^{++}.$$

Silver ethylxanthate has a solubility of 6.5×10^{-10} moles per liter and zinc ethylxanthate a solubility of 1.1×10^{-6} moles per liter. Since

a variety of grinding media tested under different conditions at speeds up to 900 to 2000 pct of the critical. On the basis of these results it is proposed that in mills provided with smooth lining grinding should be possible over a wide supercritical speed range. Although the results as reported are primarily of theoretical interest, they show, qualitatively at least, the general overall operating characteristics of peripheral discharge or of low level grate discharge mills. **5817A10.**

A Study of Various Types of Steel for Grinding Media at Climax by *Frank J. Windolph and E. J. Duggan*—The wear rates of various types of grinding balls are only part of the story at Climax. An interesting variance in grinding efficiency has been established which must be considered in selecting the most economical grinding ball. **5817A11.**

Single-Stage vs Two-Stage Grinding at Homestake by *C. E. Schmidt and F. M. Howell, Jr.*—Homestake's South Mill was remodeled in 1952-1953 with the installation of three identical milling units, each consisting of an open circuit 6x12-feet Marcy rod mill in closed circuit with a 16-ft HX Dorr classifier. Each unit will mill 1350 to 1400 tpd (4100 tpd total capacity) of −½-in. rod mill feed with the ball mill classifier overflow sizing 7 pct +100 mesh and 65 to 68 pct −200 mesh.

By 1958, an increase in milling capacity was indicated. An increase of 10 to 15 pct could be handled by existing hoisting, crushing, and treatment plants with very little additional labor required. The decision was made to install a single stage 9x11-ft ball mill of identical design to those in present use, but to use cyclones for the close circuiting. Calculations showed that the single-stage ball mill would have a capacity of some 800 tpd when taking feed identical to that of the two-stage units.

In February of 1956, this fourth unit was placed on stream and has consistently milled 775 to 825 tpd whenever ore is availabe. Maximum mill capacity is now 4850 tpd, while the yearly average is 4500 to 4550 tpd. **5817A12.**

Pebble Milling At Faraday Uranium Mines by *R. J. Roach*—The application of sized run of mine ore as grinding media to secondary grinding in the Faraday Mill is an outstanding success.

During the early investigational work on uranium metallurgy, it was realized that reagent consumption would constitute a major proportion of milling costs and that pebble milling offered an attractive means of substantially reducing the costs. The big saving has been the cost of steel balls and their handling; however there are others that, while difficult to evaluate, are nevertheless present. Among these are included a 4-pct increase in mill capacity due to the pebble consumption; a substantial reduction in the consumption of leaching reagents because of lesser amounts of abraded steel reporting in leach feed pulps; and more efficient use of power, since energy formerly expended on ball size reduction now does useful work on ore.

Pebble grinding using run of mine ore has been successfully exploited in recent years; however the changeover has necessitated the adaption of existing equipment and this has most certainly limited its use. Once the decision was made to incorporate pebble grinding into the flow sheets of the three mills planned for the Bancroft area, it marked the first time that its proponents were able to design and specify equipment specifically for pebble grinding. **5817A13.**

A Study of Grinding Ball Wear Employing Radioactive Tracers by *A. L. Wesner, M. Pobereskin, and J. E. Campbell*—A radioactive tracer technique was developed to sort and identify grinding balls. With this technique it was possible to precisely determine the wear rate of experimental ball samples under actual operating conditions in a commercial mill. The ball characteristics evaluated were composition, heat treatment, and surface treatment. This evalution was made in a dry grinding operation on cement clinker and in a wet grinding operation on cement raw materials. The relationships are shown of the wear rates to the properties of the experimental balls. **5817A13a.**

General Industrial Minerals

Joint Session with Industrial Minerals Division

2:00 pm Monday, February 17 Sky Top Room

G. W. Josephson and Norman Sather, *Chairmen*

For Abstracts, see under Industrial Minerals, page 45.

cupric and ferric ethylxanthates are known to decompose, it is not certain whether a true solubility has been determined for these salts.

The role of oxygen in the decomposition of ferric xanthate is discussed. Oxidation of ferrous iron to ferric iron by dissolved oxygen is shown to be responsible for the reduction of xanthate ion to dixanthogen.

The value of these solubility measurements in the ananlysis of practical sulfide flotation operations is considered. By an application of simple physical-chemical principles, it is reasoned that in many sulfide flotation pulps precipitation of base metal xanthates, even though not desired, cannot be prevented. **5818A15.**

Activation and Deactivation Studies with Copper on Sphalerite by *D. W. Fuerstenau, G. W. Mao, and A. M. Gaudin*—Experiments with radio copper 64 indicate that sphalerite activation is controlled by two processes: 1) rapid uptake of copper ions to form copper sulfide at the surface, in exchange for zinc ions, and 2) slow diffusion of copper ions into the sphalerite lattice across the copper sulfide layer formed during the first stage of the reaction. This slow reaction follows Carl Wagner's parabolic law.

Neither cyanide ion or copper-cyanide complex ions are adsorbed on sphalerite. Deactivation results from the sequestering of copper ions as complexes in solution; this reduces the concentration of free copper ions in solution below that necessary for activation and drives the reaction back. The distribution of copper between sphalerite surface and solution, at constant total copper, depends on the concentration of the deactivating agents in solution and on the stability of their copper complexes. **5818A15.**

Correlation of Contact Angles, Adsorption Density, Zeta Potentials, and Flotation Rate by *D. W. Fuerstenau*—Contact angles, collector adsorption densities, zeta potentials, and flotation rates of quartz with dodecylammonium acetate as collector are presented as functions of pH. The relationship which exists between these four surface and flotation phenomena is presented graphically in the paper. This relationship can be explained by the mechanism of collector adsorption. **5818A17.**

Mill Design

9:00 am Wednesday, February 19 Sky Top Room

Harry L. McNeill and Charles N. Bailey, *Chairmen*

Comparison of 2400 and 4160 Volt Distribution Systems for Concentrators by *R. M. Wilson*—Concentrating plants, in common with other types of industrial plants, cannot operate without electric power. The electric distribution system and utilization equipment, therefore, must be carefully considered in all phases of plant design. Two important aspects of proper distribution and usage of electric power are the selection of voltage levels and the methods of system grounding. These are not necessarily the most important design considerations, but are perhaps more controversial than other major points.

Relatively little advancement has been made in recent years in improving conductors; however, great progress has been made in improving insulation. Thus modern plants now find it economical to use higher voltage than they did previously. **5819A9.**

Taconite Mill Design Factors by *F. D. DeVaney and Earl R. Johnson*—Factors influencing the design of plants for the concentration of taconitic iron ores are discussed. To be economic, taconite must be treated on a large scale to secure low operating costs. This is being achieved in Minnesota taconite plants through the use of large capacity units, holding manpower to a minimum and the ready replaceability of mill equipment to secure high operating time. Major factors such as water supply, tailings disposal, power, and transportation are also given consideration. Particular attention is given to flowsheet and equipment selection rather than to building design and materials of construction. **5819A11.**

Factors in the Selection of Motors and Speed Reducers for Conveyor Drives by *Clark B. Hisler*—Conveyors provide vital connecting links in ore concentrating mill operations. A review of the elements of successful conveyor drives leads to several principle factors which bear heavily on the proper application of electrical drive systems and speed reducers. Among these factors are: operating loads, speed range, reliability, operating conditions, and belt stress limitations. Each factor is considered and its effect on the selection of electric motor drive and speed reducer evaluated. **5819A12.**

Magnetic Separation

2:00 pm Wednesday, February 19 Sky Top Room

Earl Herkenhoff and Larry Roe, *Chairmen*

Symposium on Recent Trends in Equipment and Applications

Magnetic Separation of Ores—History and New Foreign Developments by *L. A. Roe*—This paper reviews the history of magnetic separator development and the evolution of various machine designs now commercially used. Basic design data involved such as the magnetic properties of various minerals and types of permanent magnet materials are discussed.

Some of the new developments in Scandinavian and German magnetic separation practices are described. An intimate story of the development of the new Laurila (Finnish) separator complete with photographs and results of commercial operation is given. **5819P1.**

Pyrolysis and Agglomeration

Joint Session with Iron and Steel Division of The Metallurgical Society of AIME

9:00 am Thursday, February 20 Sky Top Room

F. D. DeVaney and Alan English, *Chairmen*

FluoSolids Roasting of Sulfides for Recovery of Copper, Iron, and Sulfur by *H. Kurushima and R. M. Foley*—This paper will describe an operating installation in Japan where a pyrrhotite concentrate is being roasted to produce SO_2 gas for sulfuric acid manufacture. Sulfating conditions are obtained by controlling the temperature as well as the air supply, whereby the copper contained in the pyrrhotite is converted to a soluble copper sulfate. The calcine from this roasting step is leached for copper recovery and the leach residue is sintered and utilized as blast furnace charge. Actual operating results will be given showing recoveries and operating conditions. **5820A11.**

Beneficiation of Low Grade Iron Ores Involving Direct Reduction by *Alex Stewart and Harold K. Work*—Discussed is the treatment of low grade iron ores by direct reduction in a controlled atmosphere of carbon monoxide, and under controlled operating temperatures, below the melting points of iron and its oxides in a rotary kiln using low cost nonmetallurgical solid carbon fuels. Iron ores in the range of 25 to 45 pct total iron are treated. The process can produce concentrates suitable as feed for the blast furnace, open hearth, and electric furnace. Depending upon mineralization of the ore, concentrates in the range of 95 pct total iron, 90 pct or better metallic iron, less than 2 pct silica can be produced, with an overall iron recovery of 85 to 90 pct by the use of magnetic and gravity separation following the reduction of oxides to metal. With certain types of low grade iron ores, the process produces two grades of concentrate, 60 to 80 pct of the overall concentrate containing 90 to 95 pct total iron, about 90 pct metallic iron, less than 2 pct silica, the remaining 20 to 40 pct of the overall concentrate may contain 75 to 85 pct total iron, 65 to 80 pct metallic iron, with an average of 5 pct silica, with an overall recovery of iron in the order of 85 to 95 pct, thus producing a major port of the concentrate as suitable feed for the electric and open hearth furnace, as well as the blast furnace.

Briquetting of the iron concentrate will be discussed. Some information on the use of such concentrates in the blast, electric, and open hearth furnaces will be presented. **5820A12.**

Reduction of High Grade Port Henry Magnetite Concentrates by *Earle C. Smith and Donald E. Babcock*—The R-N Process as developed at the R-N Spalding pilot plant has been applied to the reduction of highly beneficiated Port Henry magnetite concentrates of −14 mesh. The comparative analyses of the concentrate fed to the kiln and the briquetted product are given in the table.

The analysis of the briquetted product shows that the percentage of the nickel and chromium were less than 0.00 pct while the percentage of tin, antimony, lead, and bismuth were less than 0.000 pct as determined spectographicly. The reduction of these −14 mesh materials is accomplished without unusual result, and little or no difficulty. The recovery of iron values from the reduced product scribed. The results obtained in this pilot plant operation are presented together with data on the quality of product produced and the reagent cost. Th results obtained when operating the pilot plant using a tri-fatty amine supplied by General Mills, Inc., are presented with data on product quality and reagent cost. A comparison is made between the quality of product and cost of the three procedures described. **5820A16.**

Amine Extraction of Port Radium Leach Liquor by *M. E. Grimes*—The 25-year-old Port Radium operation of Eldorado Mining and Refining, in northern Canada, will adopt a solvent extraction process in 1958 to replace the existing aluminum reduction process. Laboratory and pilot plant investigations have been made of several amine solvents, a variety of kerosene-type diluents, and several alternative stripping re-agents. The type of extraction and stripping equipment best suited to the Port Radium plant has also been investigated. The plant will start up with tri isooctyl amine as solvent in a western diesel fuel oil diluent. Sodium carbonate stripping, caustic precipitation, recarbonation, and removal of sodium sulface buildup by crystallization complete the process. Individual mixers and box-type settlers will be used for each extraction and stripping stage. Instrumentation is an important feature of the plant design. Continuing laboratory work shows promise of significant improvements which may be possible after the process is on stream. **5820A17.**

Processes for Making UF_4 in Uranium Mills by *R. S. Long, J. E. Magner, and D. A. Ellis*—Several methods have been studied for processing uranium from ore to nuclear reactor grade products in a single location. Uranium mills might produce purified UF_4 instead of the crude yellow cake now being made. Two processes, developed by the Dow AEC group, are discussed in detail.

The first process consist of two solvent extraction steps. Initially, the uranium is extracted from sulfuric acid leach liquor or slurries into an aklyl phosphate solvent. The uranium is then stripped from the solvent by use of a strong chloride solution. It is then reduced and re-extracted as a heptachloride anion complex by use of an alkyl amine extractant. Finally, the reactor grade UF_4 is obtained by HF precipitation on the second solvent.

Equilibrium data and data on the reduction of uranium in chloride solutions are included.

Another process for making UF_4 consists of anion exhange followed by solvent extraction. Uranium mills using ion exchange might convert present uranium yellow cake production into UF_4 by addition of a solvent extraction step to their IX eluates, either nitrate or chloride. The uranium in the IX eluate is reduced electrolytically and extracted into a specific aklyl phosphate extractant. UF_4 is then precipitated from he solvent phase.

Current efficiency, current density, and power consumption for the reduction of the uranium are discussed. **5820A18.**

Developments in Operating Control

2:00 pm Thursday, February 20 Sky Top Room

H. E. Uhland and J. W. Snavely, *Chairmen*

The Development of a Continuous BPL Analyzer by *H. B. Graves, Jr., and Elliott Northcott*—A continuous recording BPL analyzer has been in operation at the Noralyn flotation plant of International Minerals and Chemical Corp. for the past several months. This continuous analyzer as described in this paper weighs and analyzes 1440 samples per 24-hr period. Results are recorded in less than 10 min after the sample enters the apparatus. The labor is negligible and maintenance is almost nil. The method is basically a colorimetric analysis based on the measurement of the color of *phosphovanadomolybdic acid*. A flowsheet of the analyzer is discussed as well as some of the problems which were overcome in the development work. **5820P12.**

Automatic Weighing and Ratioing of Solids by *Thomas L. Mell*—Continuous processing plants handling bulk materials have not used automatic control equipment to as great an extent as liquid processing plants. A major reason has been the lack of adequate sensing equipment for measuring the flow rates of solids.

This paper describes an electronic scale for measuring the flow of bulk material on conveyors belts. The system uses the electric strain gage load cell, industrial potentiometric recording instruments, and automatic controllers capable of operating various types of feeders. Measurement and control of several feed rates may be brought to one location under the supervision of on operator. Ben-

Analyses of Port Henry Concentrate Fed to the Kiln and the Product Produced

Component	Pct of Component in Concentrate Fed to the Kiln	Pct of the Component Present in the Briquetted Product
SiO_2	3.56	0.54
Al_2O_3	0.96	0.24
CaO	0.36	0.41
MgO	0.22	0.82
S	0.014	0.022
P	0.08	0.030
Mn	0.06	0.05
Total Fe	69.26	96.48

was in proportion with the percentage of metallization, with the yields rising as the percentage of metallization attained in the kiln was raised. The fine metallic concentrate could be briquetted with ease, using plunger-type briquetting presses with excellent briquets being obtained with little or no fines when pressures were raised to the level of about 38 tsi. In the high ranges of reduction there was a wide range of temperatures over which reduction could be carried out, provided consideration is given to the control of the carbon content of the reduced product, with appropriate cooling of the higher carbon product.

A series of tests, with from 20 to 60 pct of the charge as iron briquets, were made in the Chicago electric furnace shop of Republic Steel. The product proved to be a satisfactory melting stock, and particularly useful where a premium value for its low alloy and low residual of contaminant elements is desirable. **5820A13.**

Solution and Precipitation

Joint Session with Extractive Metallurgy Division of The Metallurgical Society of AIME

9:00 am Thursday, February 20 Penn Top South

A. L. Wesner and John Dasher, *Chairmen*

Resin-in-Pulp Process at Mines Development, Inc., by *H. D. Webb and G. F. Richards*—Resin-in-pulp, or RIP, is the process of passing uranium-bearing, unclassified acid leach liquors through a moving bed of ion exchange resins. The resins absorb the uranium ions, and the barren leach liquors—together with the slimes—are directed to tailings. Uranium is recovered from the resins by *eluting* solutions.

Uranium ore at the Edgemont Mill of Mines Development is a loosely cemented, easily leached sandstone containing a minimum of slime. Process steps include grinding, acid leaching, sand-slime separation, RIP, and precipitation and filtering of uranium values. Character of the ore, together with unique processing techniques and close metallurgical control, gives high plant efficiency and low costs.

Feed to the ion-exchange system is directed to eight banks on a countercurrent loading cycle. Cycle change is approximately every 2 hr. Loadings of 5 lb per cu ft are not unusual. Sodium nitrate, rather than the usual ammonium nitrate, is used for elution, and pregnant liquors from the RIP are precipitated with MgO.

Various problems encountered in the RIP section include failure of the screen cloth in the baskets, corrosion and deterioration of electronic control apparatus, and difficulty with gypsum accumulations in the circuit.

Operating procedures, problems, and control techniques are discussed. Also reviewed are data on plant efficiency, recoveries, and operating costs. **5820A15.**

Climax Uranium Company's Approach to Vanadium Recovery by Solvent Extraction by *R. E. Musgrove, E. E. Maurer, and R. E. Fischer*—A description of the existing Climax Uranium Co. circuit for the recovery of vanadium is presented with data on the quality of product and the reagent cost of production. The flowsheet of a semi-pilot plant solvent extraction for vanadium is de-

efits obtainable from centralized automatic control include lower cost, better product uniformity, and higher production by operating process equipment at its capacity.

Typical automatic control systems are described using this measuring system, including descriptions of the instruments used and how they fit in with the process, how the plants operate and maintain the controls, and the results of actual operating experience. Information is also given on the proper design of conveyors and feeding equipment for good control. **5820P13.**

Hydraulic Solids Flowmetering by *E. J. Klein and E. F. Nagle*—This paper presents an illustrated description of a flow metering system, where hydraulic means are used to move solid materials. Engineering considerations of the orifice design and purging apparatus are discussed. In addition to the velocity and/or flow measurement, density measurement, the compensation of the flow measurement for variations in density, and automatic net solids flow rate computation and integration are discussed. Details of systems already proven to be successful and useful are illustrated in the presentation. **5820P15.**

Gamma Ray Gages in Beneficiation Plants by *John R. Riede*—Accurate and continuous full stream measurement of percent solids, density, or the specific gravity of slurries in ore beneficiation plants has long been a problem. The gamma ray gage which can continuously and very accurately make these measurements has opened a whole new field of reliable automation in processes which are much dependent on them.

This paper will briefly dscribe how these gages work, their advantages, cost, and reliability. It will also cover some of the existing installations and will point out other ideal applications in the beneficiation industry. The problem of radiological safety procedures encountered when these devices are used will also be described. **5820P16.**

Symposium. Thickening, Filtration, and Flocculation

Joint Session with Extractive Metallurgy Division of The Metallurgical Society of AIME

2:00 pm Thursday, February 20 Penn Top South

A. H. Ross and R. T. Davis, *Chairmen*

There are no abstracts. Panel participants and summary papers are listed in the program, page 64.

Mining, Geology, and Geophysics Division

Some Economic Considerations in Exploration Geology

9:00 am Wednesday, February 19 Georgian Room

James O. Harder and Edward L. Tullis, *Chairmen*

Some Legal Problems Encountered in the Acquisition of New Mineral Property by *R. E. Driscoll, Jr.*—A brief description is given of the necessity for close collaboration between the exploration geologist and his attorney. Some of the pitfalls involve the different laws and rules in different states and districts and those that affect different types of deposits. Some sources of land status information include 1) methods of determining whether or not land is open to location for specific minerals, and, if not, the type of withdrawal; 2) methods of research in a government land office; and 3) necessity of abstracts. When a discovery is made on public domain, there are certain questions to be answered and requirements; concerning: 1) what is a legal discovery? 2) the history of the law of discovery and criticism of these rules as applied to modern exploration methods, 3) how to stake mineral claims, and 4) doctrine of *pedis possessio*. When a discovery is made on private property, the methods of acquiring mineral rights are outlined with a brief explanation of the advantages and disadvantages of each: 1) out-right purchase, 2) leasing, 3) lease and bond, and 4) profit sharing. Some comments are made on the present mining codes, with emphasis on the archaism of present mining laws as applied

to both mining locations and minerals acquired under the leasing acts. **5819A1.**

The Exploration Geologist's Work in Acquisition of Mineral Properties by *Manning W. Cox*—The exploration geologist makes business recommendations in appraisal, acquisition, or disposal of mineral properties because success in mining ventures basically depends upon existence of a commercially valuable natural resource. He must combine geologic skill with knowledge of exploration, operating, marketing, business, and law, or work with experts in other fields. Mineral lands may be held in fee or only by possession. Lands may be acquired by pre-emption under law, by governmental concession or lease, or from private persons by purchase, lease, or sharing.

Estimate of unit value and cost, uniformity of composition and occurrence, and certainty of occurrence affect his recommendations. Time-work required to judge the occurrence partly determines necessary business flexibility. State of development or data available, affects time needed, risk justified, and set limits to any proposal.

Timing within the general economic cycle, economics of the desired commodity, and business of the principal affect his negotiations. A boom camp creates special problems.

The nature of the principal's business influences type and details of possible transactions. Prospectors, land or stock speculators, miners, processors, and manufacturers may insist on special business conditions. **5819A2.**

Economics of Geologic Exploration by *D. M. Davidson*—The economics of geologic exploration have changed materially in the past decade as a result of three factors: increased wages, increased cost of materials, and much greater complexity in methods of exploration. Base wages have gone up approximately 100 pct, materials used in mining and exploration have also increased approximately 100 pct, while a variety of expensive methods now in common use in surface exploration were rare or even unknown in 1946.

The geologic methods used for extending known ore underground do not differ materially now from those used ten years ago. The emphasis is still on structural control for ferreting out extensions of known ore bodies. The costs, however, have increased—first because of an increase in labor rates and materials and also because of the greater difficulty in finding more obscure types of ore bodies nowadays. The foregoing applies to extensions of ore in known districts. In prospecting virgin territory for buried ore bodies, the complexion has changed greatly. The former *spot examination* has given way to the well organized present-day campaign which begins with an idea and goes through the stages of land acquisition, aerial photography, photogeology, aerial geophysics, ground geophysics, and ground geology. Synthesis of all pertinent information may justify ensuing stages of diamond drilling and underground exploration. **5819A3.**

Valuation of a Mineral Deposit by *A. L. Slaughter*—The final question to be answered when considering the potentialities of a mineral deposit is, what profit can my company reasonably expect to make by acquiring this property, developing it, and putting it into production? The answer must be based on the consideration of numerous factors and expressed as a figure for final profit per ton, money which can be used to return investment and pay dividends.

The assumption is made that the presence of mineral has been proven, sufficient exploration been done to indicate a minable ore body, and some arrangements made for acquiring the land. Exploration costs have been incurred and probably part of the acquisition costs have been paid. Now it must be decided whether or not the balance of the acquisition costs can be paid, the ore can be mined, the valuable constituent removed and sold, taxes paid, and a sufficient profit can be made to make the enterprise worthwhile.

Basic knowledge, such as grade and tonnage of ore has been obtained as a result of the exploration work. This is the base from which ultimate profit can be estimated. Cost of mining, cost of treatment, and percentage of recovery are factors of a technical nature. Beyond all these and just as important as an item of cost, is taxes. Depletion, as applied to mining, is important in the tax picture. Some hypothetical cases are considered. **5819A4.**

Daniel C. Jackling Lecture

2:00 pm Wednesday, February 19 Grand Ballroom

Planning for Deep Mining at Homestake:

Abbott H. Shoemaker

Preplanning Safety in the Uranium Industry by *John E. Bailey and Brower Dellinger* (alternate)—This discussion is on uranium from the underground and open pit mines to the final stages of fuel with the theme *preplanning safety*. The most troublesome hazard in mining—falls of back and walls—is elaborated on because of the seriousness of this hazard. Radon gas and its effects are discussed, and a comparison is made with other noxious and flammable gases commonly found in underground mines, to bring out the fact that this problem is no more difficult to overcome than other similar problems we have had in the past.

The finished product at reduction plants is discussed and a comparison of the hazard from this product with the hazards from everyday operations in many similar ore processing plants is made to point out adequate precautions needed to minimize the danger from this source.

An example of preplanned safety is shown in the record of the AEC over a given period of years when their program was in the stepped-up stages of research.

There is some discussion on radiation hazards, monitoring, and safe doses of radiation, along with the terms industry uses to indicate measurement of radiation doses and safe limitations when working in proximity of radioactive material. This is in laymen's terms of recognized procedures used in industry.

Throughout this discussion, education and training, are carried to emphasize the need for this type of planning for safety and efficiency. **5817P1.**

Increased Safety, Better Production, Through Use of Communication and Electronic Equipment by *Earl A. Berry*—A review of conditions which brought about the need for electronic equipment to gain increased safety and better production in underground mines. A discussion of equipment now available for this purpose, its functions and applications. Also a preview and demonstration of electronic equipment which can and will be generally used in accomplishing greater gains in increased production and safety. The main purpose is to acquaint mining personnel to the fact there is a wealth of electronic equipment available to accomplish many tasks and to convey information. A method of solving problems that have long been accepted in mining as a necessary evil because no other practical alternative was available. The simple demonstrated facts are only limited by the extent of the users imagination and ingenuity. **5817P2.**

Symposium on Safety and Health

Health and Safety Activities of the Bureau of Mines in the Metallic and Nonmetallic Mining Industry by *James Westfield*—Described are various health and safety activities of the Bureau of Mines and the services given to the mineral industries. Future health and safety work planned for the metal mining industry and cooperation of management, labor, State mining departments, and the USBM are discussed. Briefly touched upon is the injury-frequency experience of the various commodity groups of the metal mining industry. **5817P3.**

What Management Can Do to Prevent Accidents by *John A. Johnson*—Accident prevention training for employes and supervisors is one of the most effective methods of preventing injuries in the mineral industries, as it makes the employes safety conscious. It is management's responsibility to provide safety training courses for its employes, safe and healthful working places, proper equipment and tools, and proper supplies and materials. Money spent on safety training now will yield big dividends in the future. **5817P3.**

Role of the Public Health Service in Mine Health by *Henry Newton Doyle*—Present activities of the Public Health Service in the study of health problems in the mining industry will be covered. The active interest of the Public Health Service in this field dates back to 1914 when the Service, in cooperation with the U. S. Bureau of Mines, undertook a series of studies in the mining industry pertaining to silicosis. These studies culminated in 1935 when it was believed that the information was sufficient to enable the mining industry to instill effective control measures to prevent silicosis. In 1955, 20 years after the culmination of these investigations, a study was made of the prevalence of silicosis in the dusty trades. This study revealed that of 10,400 compensable cases reported in the five-year period 1950 through 1954, 16 pct came from the metal mining industry. If one assumes that, for each disabling case of silicosis there are four nondisabling cases, as we have found in past studies, then it is possible that there may be over 6000 potential disabling cases in the metal mining industry. In this study complete

Mining Subdivision

Open Pit Mining

9:30 am Monday, February 17 Georgian Room

W. J. Rundle, *Chairman*

Pima Pit and Haulage Facility by *R. E. Thurmond*—The Pima pit is an oval-shaped excavation with a long incline access to the third bench. A ramp system is maintained within the pit as access to lower benches. Only one side is carried as a final slope; others are continually being worked. Final slopes are 1.45 to 1 in the alluvium, and 1 to 1 in the rock. Daily production is 4,000 tons of ore and 12,000 cu yd of waste.

Alluvial stripping is done with scrapers using single push loading. A rotary drill is used for drilling 9 in. blast holes. Ammonium nitrate blasting agent is used for the most part. Considerable secondary drilling is required to size material for skip hoisting.

Three diesel-powered 2½-cu-yd shovels were selected because of a need for mobility and sizing of material. A fleet of 11 trucks is used along with a skip hoist. The skip railway is on the final slope on a 38° incline. Ore and waste are hoisted 291 ft vertically and dumped into receiving hoppers 45 ft above the surface. Five 16-cu-yd trucks are scheduled for hauling to the skips in the pit and three 34-cu-yd trucks for hauling from the receiving hoppers. The hoist is powered by four 500 hp ac wound rotor motors. The two drums (6.2x7.8 ft) are clutch coupled and are operated in balance. Normal daily production is 6000 cu yd for the hoist.

Truck availability has improved substantially with the hoist; however, track and skip maintenance have increased the maintenance load. **5817A1.**

Mining of Magnetite and Martite at Benson Mine by *Arthur F. Peterson, Jr. and William P. Bach*—The purpose of this paper will be to describe open pit mining at Jones & Laughlin's New York Ore Div. in relation to some of the special problems encountered. While it is not implied that any of these problems are unique in themselves, they present an interesting challenge to the operator when taken as a group.

Accordingly, the mining operation will be described with special emphasis on the following factors:

1) *Shape of ore body:* Since it is long and narrow access roads, haulage distances, equipment movement, etc., require special attention.

2) *Nature of Mineral Occurrence:* Since the magnetite, martite, and rock are handled separately but occur in many alternating zones rather than in a few distinct areas, mining must be planned carefully.

3) *Plant Schedule:* The surface plant runs 357 days a year, 24 hr per day, with three distinct concentrating sections. The mine must keep these sections supplied at all times.

4) *Climatic Conditions:* Not only subzero weather, but wide rapid temperature changes and considerable snow complicate winter operations. **5817A3.**

Estimating Data for Haulage Trucks—Open Pit Mines by *Howard A. Wilmeth*—The paper presents a method developed at Chino Mines Div., Kennecott Copper Corp., for computing trip time of haulage trucks under any known haulage conditions. Total trip time is a combination of times for loading, travel loaded, spotting and unloading, returning empty, and spotting at a power shovel. Data was developed for estimating each portion of total trip time by use of a combination of time study and kinetic energy formula. Time of travel over a known road condition can be read directly from average performance charts by reference to a profile of the haulage road showing distances and grades. The data is useful in developing stripping programs using truck haulage, laying out haulage roads, and determining the optimum number of trucks assigned to a shovel under a given haulage setup. The data is useful in estimating future haulage costs and outlines an expense breakdown for reporting meaningful costs to reflect the efficiencies of a given operation. The use of the factor *ton-time per operating shift* is suggested to measure the efficiency of the truck fleet on any haulage layout. **5817A2.**

Safety and Health

2:30 pm Monday, February 17 Ivy Suite

F. C. Green and J. C. Landenberger, *Chairmen*

occupational histories were obtainable for 509 silicotic miners. Of this number, 84 pct had their initial exposure *prior* to 1935, the year in which the mining industry began an extensive dust control program. It would thus appear that in 1957 the silicosis problem in the metal mining industry is not as acute as it was two decades ago. However, it would be premature to conclude that, since only 16 pct of the cases had their exposure subsequent to the installation of control measures, the problem has largely been solved.

In addition to the silicosis study, the Public Health Service has been working very closely with the mining industry in the determination of health hazards in uranium mining. Here we have found a significant health hazard due to the presence of radiation, gas and dust. Control methods have been worked out.

Several potential health problems in the mining industry are yet in need of investigation. These relate to the use of diesel engines in underground operations and especially the toxicology of some of the materials which are coming into industrial prominence, such as zirconium, selenium, tellurium, colombium, and others. **5817P3.**

A Challenge to the States and to Industry on Health and Safety Jurisdiction by *M. P. Romney*—Even though off-job accidents among employes take a higher toll of lives and working time than do on-job accidents, the *on-job* accidents received the more critical publicity. Zero frequency experience is the desirable goal and every effort should be made to approach it.

The responsibility for accident prevention rests with industry management and employes. The established and generally approved jurisdiction for regulation, inspection, and control rests with the States. Recently, bills have been introduced in Congress proposing broad increases in inspection and investigation powers of Federal agencies. Of particular concern to the mining industry are the proposals to give mandatory powers to USBM for such activities in metal and nonmetallic mines and quarries.

Industry and most State agencies have opposed those proposals on the premise that control and regulation of such matters are primarily State functions. They have, in conjunction with this position, urged cooperation with Federal agencies having contacts and doing research in health and safety.

Effective State administration, effective industry programs, and cooperative support of Federal agencies make an ideal setup for the desired progress in industrial health and safety.

To insure continuity of State jurisdiction and industry responsibility under that jurisdiction, both the State and industry face a constant challenge of accomplishment. Many states are re-examining both the powers and the organization of their health and safety agencies for the purpose of making them more effective. Both State agencies and industry in some States have developed a high degree of cooperation with USBM and the Occupational Health Div. of the Public Health Services in both immediate problems and those requiring research. **5817P3.**

General Mining

9:00 am Tuesday, February 18 Ivy Suite

Hugh J. Leach, *Chairman*

Panel Discussion on Use of Ammonium Nitrate Fertilizer for Blasting

The Use of Ammonium Nitrate for Blasting at the Mesabi Range Mines by *Charles H. Grant*—A fertilizer grade of ammonium nitrate was first used on the Mesabi Iron Range at Cleveland-Cliffs Hawkins Mine in April of 1956. A mixture of 1 gal of feul oil to each 80 lb of ammonium nitrate issued with the material being mixed before loading the holes. Fertilizer grade of ammonium nitrate has proved to be just as effective in dry areas as specially prepared ammonium nitrate powders containing their own carbonaceous material and costing twice the amount. Ammonium nitrate has a tendency to take on water from the air and because of this, should be detonated within 8 hr after loading if a blast is to be effective. In order to meet this requirement, the number of holes blasted at one time has been reduced. Various methods of packaging ammonium nitrate to permit its use in wet drill holes have been tried. Some were successful, others not. The most effective method tried to date used a mixture of grain and prills to produce a specific gravity of more than one. Primers of varied sizes have also been tried with best results obtained by using small primers closely spaced. Vertilizer grade of ammonium nitrate has reduced blasting costs on the mesabi Iron Range without creating any unnecessary hazards and there is no doubt that it is here to stay. **5818A1.**

The Use and Economy of Ammonium Nitrate Fertilizer Grade in the Open Pit Operations of The Anaconda Co. in the Western United States and Mexico by *A. C. Bigley*—There have been several patents granted regarding the use of ammonium nitrate mixed with a carbonaceous material for use as a blasting agent. These have been granted in 1885, 1912, 1935, and 1955. In 1955, a patent was granted to Lee and Akre pertaining to placing a mixture of carbon black and ammonium nitrate in polyethylene bags to be used in blast holes.

The Anaconda Co. uses ammonium nitrate as a blasting agent at mines in the western states and Mexico, namely the Yerington Mine in New Mexico, the Berkely Pit at Butte, Mont., and also, Cananea, Sonora, Mexico. The usual method is to mix prilled ammonium, nitrate with diesel fuel at the collar of the hole. Various types of primers are used for detonation.

Blasting costs have been substantially reduced, amounting to over 40 pct saved in each case. Breakage and fragmentation have been excellent. **5818A1.**

Blasting with Ammonium Nitrate by *Walter M. Chapman*—The National Lead Co. at the MacIntyre Development, Tahawus, N. Y., produces ilmenite and magnetite concentrate from a heavy dense ore that is mined from its 17,000 tpd open pit.

From 1942 until 1955, 90 pct gelatin dynamite was used exclusively as the explosive. In 1955, tests of several canned blasting agents were conducted, resulting in their adoption for primary blasting to the exclusion of dynamite.

Recently, prilled ammonium nitrate fertilizer mixed with oil has been substituted for the low-density, top part of the charge in 6½-in. diam dry holes with no sacrifice in fragmentation. The cost of the top load in those holes was reduced by 67 pct, and the cost of the entire load by 11 pct.

Of the primary explosive now used at MacIntyre Development 20 pct is fertilizer. Continued experimentation is expected to further increase that percentage and further reduce blasting costs. **5818A1.**

Panel on Use of Conveyor Belts in Underground Metal Mines

Conveyor Belts at Miami Copper Co. by *J. B. Fletcher*—Miami Copper Co. has used belt conveyors underground since 1947 as auxiliary haulage to the primary track and trolley haulage which was installed many years ago.

The irregular bottom contour of the ore body, sometimes approaching within 25 ft of the established haulage level, and sometimes 250 ft above the haulage level, made belt conveyors economical for gathering and delivering to track haulage.

The operating staff has designed and built a hopper which feeds the ore onto the belt in a satisfactory manner. Dust control and safety can be adequately handled.

Both installation costs and maintenance costs of the belt conveyors have proven more economical that the corresponding costs for track haulage. **5818A2.**

Underground Conveyor Experience at Inland's Underground Mines by *H. M. Graff and James R. Gronseth*—Inland's conveyor belt experience in underground mines started with the installation of coveyors on a main haulage level of the Sherwood Mine in 1947. This proved so successful that the conveyors have been used extensively to supplement the original installation as the development of the mine has progressed laterally and downward. An inclined conveyor drift was driven in preference to sinking the shaft 200 ft. At the Bristol Mine one main level was similarly equipped in 1951 but the conveyors have since been completely removed in favor of rail haulage. The relative merits of belt conveyors and rail equipment must be evaluated in each situation depending upon the tonnages, distances, and special problems involved. Development work can usually be much more economical if conveyors intended for production haulage are installed as the drifts advance. The design of chutes, feeders, and transfer points to require a minimum of man power is impotant particularly when handling small tonages by conveyors. Since the installation cost is usually high, the operating and maintenance cost must be as low as possible. Some complications arise because of the need to be able to measure separately the material removd from each mining contract—for incentive computation or royalty payments. Conveyors are also used for special problems such as relieving the water problem in a scraper drift. **5818A2.**

Canadian-Latin American Session

2:00 pm Thursday, February 20 Georgian Room

John W. Chandler and J. D. Bryce, *Chairmen*

The Bicroft Uranium Mines Operation by *J. D. Bryce and J. M. Thompson*—The paper covers all phases of operations at the Bicroft uranium mine with particular emphasis on milling and on grade control in mining operations.

The Bicroft mine is located in the Bancroft area in Haliburton County in southeastern Ontario. The ore occurs within pegmatite granite and pyroxene syenite dikes transgessing amphibolite gneisses. Radioactivity is confined to the dikes and the uranium ore minerals are largely uranothorite and uraninite. It is believed that the Bancroft pegmatite ores are the only uranium ores of this type presently being mined on the North American continent. Dimensions of the ore lenses are relatively small and a large number of working places are required to support a 1200 tpd milling rate. Grade control is maintained by a relatively large staff of geologists in combination with careful mining practices including rock bolting both in the footwall and hanging walls.

The mill is a sulfuric acid leach process plant originally designed to handle 1000 tpd. Unusual features are ore pebble mills for secondary grinding and the use of countercurrent decantation to obtain the pregnant solution. The mill has gradually been worked up to the present rate of 1200 tpd by various modifications and revised operating procedures. Ion exchange is used to upgrade the pregnant solution from which the uranium is then precipitated out by the magnesia process. After drying the 70 pct uranium concentrate is shipped to either Canadian or American plants for futher processing. **5820P1.**

Open Pit Mining Operations—Knob Lake, Canada, Iron Ore Co. of Canada by *A. E. Moss*—A very brief history of discovery and development of the direct shipping iron ore deposits which lie astraddle of the Quebec-Labrador boundary in northeastern Canada. Decision to proceed with production and summary of activities during construction period.

Production commenced in mid-summer of 1954 wtih steady increase each season. Production in 1957 was just over 13 million long tons. Standard open pit mining methods employed using diesel haulage trucks for transporting ore from electric shovels to crushing plants. Ore conveyed from crushers by conveyor belt to railroad loading pocket. Ore hauled from mine to tide water port at Sept Iles, a distance of 360 miles by rail using cars with capacity of 85 long tons.

Selective mining problems discussed to abrupt changes in grade of ore. Close sampling in the pits and detailed mapping necessary for grade control. Due to freezing temperatures certain precautions necessary to avoid delay in ore shipping operations during spring and late fall. Severe mid-winter conditions dictate procedures and methods to avoid costly delays due to failure of equipment. **5820P2.**

Mining at Eagle-Picher's Esmeralda Unit, Parral, Mexico by *R. B. Taylor*—The Esmeralda Pb-Zn-Au orebody was located by surface diamond drilling in 1946 to depth and on the lateral extensions of small workings started unsuccessfully by a silver mining company early in this century. Production of lead and zinc concentrates by differential flotation started late in 1948.

The orebody is a steeply dipping quartz fluorite vein in monzonite. Vein material of ore grade is remarkably continuous both horizontally and vertically, although mining widths vary from 6 to 40 ft.

Extraction is by various shrinkage stoping methods, since both ore and monzonite walls stand well. In the narrower sections, air leg drilling with tungsten carbide tipped rods has proven most satisfactory. For sections over 10 ft in width, a jumbo system of shrinkage mining has been developed employing an air bulldozer and converted wagon drills. After the swell is pulled, the dozer levels an entire length of stope floor for the jumbos, which drill out the next stope lift with up holes.

Ore extraction is by mucking machine draw points and a new design has been developed at the property. Underground haulage is by conventional track to an ore pass system, pan feeder, and underground crusher. **5820P3.**

The Moa Bay-Port Nickel Project—New U. S. Nickel and Cobalt from Cuban Ores by *Forbes K. Wilson*—The paper will generally describe the new project by which Moa Bay Mining Co. will mine and process nickel and cobalt ores at Moa Bay, Cuba, for further refinement at Port Nickel, La., by Cuban American Nickel Co. Pro-

Raising By Use of A Cage by *John C. Wangaard*—A method of raising by use of a cage has been used with considerable success at the Cary Mine, Hurley, Wis., on the Gogebic Iron Range. The Cary Mine is owned by the Odanah Iron Co.-Pickands, Mather and Co., managers. This method is known to have been used previously at Tennessee Copper and probably in other districts.

In general it consists in the use of a drill hole between levels through which to pass a hoisting rope to raise and lower a light cage which is used as a working platform. A hole approximately 4 in. diam is drilled between levels by means of a diamond or a percussion drill and a small utility hoist is set up on the level above to handle the cage. The cage consists of a steel framework covered with wire mesh. At the start of a cycle the hoisting rope is lowered through the hole to the level below. The rope is attached to the cage and the cage hoisted to the face where it serves as the working platform. Communication between the cage and the hoistman is maintained by means of a regular bell signal system. A phone system between the bottom of the raise and the hoistman is also established. Both inclined and vertical raises up to 210 ft in height have been driven by this method with a substantial improvement in efficiency. **5818A3.**

General Mining

9:00 am Thursday, February 20 Georgian Room

George W. Wunder, *Chairman*

Mining Research in Europe by *Leonard Obert*—Twenty government, industry, and institution laboratories in six northern European countries were visited to ascertain the extent and type of mining research projects that are under investigation and the progress to date. It was found that in general the European laboratories are well staffed and equipped and that each of the countries is expending a relatively large effort on research. Particular emphasis is being given to fundamental studies related to rock mechanics and ground pressure problems. A variety of instruments have been developed for ground pressure measurements, one of which is of particular importance because it can be employed to measure the absolute rock stress both at the boundary of mine openings and at considerable distance in the undisturbed rock. **5820A1.**

Statistical Method of Calculating and Analyzing Ore Reserves by *John A. Patterson*—An orebody has varying amounts of different grade material, and a plot of the amount at each grade will be a log normal distribution curve. A cut-off grade as used in reserve computations eliminates a certain portion of the lower grade fractions of an orebody. The rest is blended mathematically to produce an average grade. Usually one cutoff is selected one average grade and tonnage calculated. Statistical methods enable us to develop a curve of the relationships between these variables.

If we have an orebody that has been sampled sufficiently, we can make an array of the lengths of sample at various grades. The total sample lengths in each grade bracket will be proportional to tonnage for uniform or random sample patterns. A cumulative plot of these tonnages or footages will show the change in tonnage as the cutoff grade is changed.

The area under this tons vs cut-off grade curve is proportional to the amount of contained material in the ore. Using this area, we can calculate average grades and construct a curve of the variation in average grade with change in cut-off grade. Combining this data on tons and grade with price will allow calculation of dollars contained in the ore for a particular cut-off. By subtracting calculated mining costs, we can obtain the net profit. We find on plotting a curve of net profit vs cut-off that there is a cut-off at which a maximum profit will be obtained. **5820A2.**

Blasting Vibrations—Cause and Effect by *Lewis D. Leet*—By use of a movie, the author shows the causes and effects of blasting vibrations. The geologist uses records of shockwaves as one of the techniques of prospecting. The author wrote and appeared in the film. **5820A3.**

Fundamental Studies of Percussion Drilling by *Howard Levi Hartman*—Certain fundamental aspects of rock penetration by single impact blows have been studied in the laboratory to further our basic knowledge of percussion drilling processes. Experiments were carried out on synthetic stone using a calibrated drop tester and assorted falling weights and bits to permit measurements of crater geometry and observation of rock failure under impact. Included in the variables studied were effects of bit shape (wedge, die, and hemisphere), blow energy, blow velocity, transfer of impact to bit, and blow indexing. **5820A4.**

duction, to begin in mid-1959, will be 50,000,000 lb of nickel metal and 4,400,000 lb of cobalt metal annually.

The paper will cover 1) history and description of the Cuban orebodies; 2) mining methods at Moa Bay; 3) transportation of the ore from mines to the Moa Bay processing plant; 4) shipping of the resulting concentrates to a refinery at Port Nickel, La., and shipping of processing materials to Cuba on the return trip.

Accompanying the paper will be silent color films showing progress to date at the plant site in Cuba. **5820P4.**

Geology Subdivision

Selected Geologic Topics

9:30 am Monday, February 17 West Room

T. N. Walthier and Charles Meyer, *Chairmen*

Factors Controlling the Localization of Ore Deposits in the Shullsburg Area, Wisconsin-Illinois Zinc-Lead District by *Robert R. Reynolds*—The majority of the Zn-Pb orebodies near Shullsburg, Wis. are of the pitch-flat type first described by T. C. Chamberlin. A study of about 1000 exploratory churn drill holes shows conclusively that solution of two limestone members (Oilrock and Glassrock) in an otherwise dolomitic section has been largely responsible for the formation of the pitch-flat structure in which the ore occurs. It has been possible to correlate the degree of solutional thinning of the Oilrock and Glassrock with the thickness of ore mineralization. Thus, the greater the thinning by solution, the more extensive the collapse of the overlying competent beds, forming the pitch structure. Correspondingly, incipient to poorly developed ore deposits show much less solutional thinning of the limy members.

Successful exploration techniques are discussed with emphasis on structure, degree of solutional thinning, and halo mineralization as the chief criteria to be used in finding an ore deposit.

It is hypothecated that minor adjustments of the pre-Cambrian basement rocks have been responsible for the complex minor folding in the overlying Paleozoic sediments. It is further hypothecated that a large body of magma was intruded into the pre-Cambrian rocks underlying the district, but did not rise high enough to send out any apophyses into the overlying sediments. This hypothetical body of magma is also suggested as the probable source of the mineralizing agencies which were able to rise into the overlying sediments through faults in the roof of the pluton. **5817A5.**

Some Considerations in Determining the Origin of Ore Deposits of the Mississippi Valley Type by *E. L. Ohle*—Ore deposits recognized as belonging to the Mississippi Valley type are found on several continents. The general characteristics of the deposits as a group are outlined and a review is given of the advances that have been made in recent years in our knowledge of their distribution and geology.

Although each deposit is distinctive in some aspects of structure, mineralogy, texture, or general geologic setting, there is so much similarity in all of the deposits that is seems necessary for all of them to have had a similar mode of origin—whatever that may be. Consideration of the deposits as a group rather than individually offers many advantages in trying to decide what the origin many have been, for the amount of limiting evidence which the hypothesis must fit is greatly increased.

The five principal genetic hypotheses that have been proposed for individual deposits are examined in the light of the group approach. Although the hydrothermal theory explains many things better than the other theories, it must be somewhat modified to account for the great size of the Mississippi Valley-type districts and the absence of igneous rocks. **5817A6.**

Inferred Assemblages of Mineral Phases in the System Cu-Fe-As-S by *Hugh McKinstry*—The number of minerals than can occur together in equilibrium in limited by requirements of the phase rule. A sulfide ore deposit can be regarded as the result of a sequence of phase assemblages, usually becoming progressively richer in sulfur with progress of deposition or crystallization. Progress from one assemblage to another is marked by disappearance of one or more minerals and appearance of one or more others, often recorded in the form of replacement textures.

Mineral assemblages for three systems and the resultant quaternary system are presented in the form of phase diagrams inferred from many records of natural occurrences.

In any district of copper ores, the number of assemblages present is less than could be formed from the elements available and is controlled presumable by relative activities of components under the geological conditions existing during and after ore deposition. A number of familiar districts occupy their own characteristic fields in the phase diagram. **5817A7.**

Sulfide Systems as Geological Thermometers by *Gunnar Kullerud*—Numerous methods have been applied in efforts to estimate temperatures of formation of sulfide minerals. Only two of these methods have been sufficiently studied and developed to the point where we can feel reasonably sure that, when properly used, they can provide results which reflect the temperature conditions during sulfide formation. The first of these two methods is based upon limits of stability of minerals or mineral assemblages. The stability of pyrite and of covellite and the stabilities of mineral assemblages in the Fe-S-O system, all recently experimentally determined, are examples of this method. The second method is based upon concentrations of elements in solid solutions. The iron content of sphalerites formed in equilibrium with pyrrhotite, and the iron deficiency of pyrrhotites in equilibrium with pyrite, are examples of this method. The first method can be used to indicate the pressure-temperature range within which a mineral or mineral assemblage must have formed. The second method is based upon uniform variations in mix-crystal composition as functions primarily of temperature and secondarily of pressure, etc. By application of two or more types of sulfide mix crystals formed in equilibrium in nature, temperatures may be obtained for cross checking purposes. Combination of the two methods makes it possible in principle to determine both temperature and partial sulfur pressure prevailing during ore deposition. The methods have been applied to suites of specimens from numerous localities and have indicated that important temperature gradients existed during ore formation. **5817A8.**

Time Aspects of Geothermometry by *R. J. P. Lyon*—Marked incompatibilities exist in depositional times derived from laboratory diffusion studies on naturally intergrown sulfides and those considered likely for most ore-forming processes, particularly where ores are formed (or modified) by regional metamorphism. Schwartz decided in 1931 that 475°C was the minimum temperature at which he could restore the solid solution from natural bornite-chalcopyrite intergrowths; however, he also stated that the reformed intergrowths could be preserved only if the time of cooling from 475°C to room temperature was less than 24 hr.

The diffusion rates in two Australian ores have been studied in detail. In Pine Valley ore, bornite, chalcopyrite, and tetrahedrite occur intergrown in fixed proportions. Heat treatment restores a homogeneous solid solution at 500°C in 100 hr. The pattern of natural intergrowths can be simulated only if that solid solution is chilled to below 275°C in a few minutes. The ore must have been introduced 200° to 250°C hotter than that of the country rock and frozen in place.

In Aberfoyle ore, sphalerite, stannite, and chalcopyrite each occur containing the other two as intergrowths. Data obtained from the iron content of the sphalerite, and from heat treament of the ore, indicate that deposition occurred about 600°C. Chilling by the country rock had arrested the unmixing of the three blende group solid solutions. Annealing experiments above 350°C led to further precipitation from the solid solutions, and to significant segregation by solid diffusion within one week indicating that both deposition and cooling of the ore were rapid processes—completed in a matter of days. The possibility that there are unsuspected variables in the diffusion experiments should be investigated. **5817A9.**

Copper Mineralization and Regional Structure in Arizona, New Mexico, and Sonora

Joint Session with Society of Economic Geologists

2:30 pm Monday, February 18 West Room

W. C. Lacy (Geol) and K. Cochran (SEG), *Chairmen*

Relation of Mining Districts to Regional Tectonics, With Special Reference to Southern Arizona and Southwestern New Mexico by *S. E. Jerome and D. R. Cook*—By comparing metallization maps with geologic and tectonic maps, emphasis is given to the close correspondence of western mining districts with igneous centers and to the importance of regional tectonics in localizing these centers as well as individual ore deposits within districts. A review of the geologic history of southern Arizona and southwestern and their origin, with particular reference to those of the Cananea, Sonora, Mexico, district. The argument is advanced that in general the *explosive* type is relatively rare by comparison to the *slump breccia* type of Cananea and other districts. The nature of the breccia pipe filling is described in many of the examples cited, and comparisons are made between breccia pipes and pebble dikes illustrating probable differences in origin. **5817P7.**

The Origin of the Southwest Metallogenic Province by *Harrison A. Schmitt*—The problem is essentially this: Why are the two metallogenic provinces of northwest and southwest Arizona, or—if you wish a single northwest belt—where they are, or is it? The southeast province, including southwest New Mexico and northern Sonora, Mexico, an area 300 miles in diameter, produces copper equivalent to 55 pct of the total United States production.

The three states area is marked by the overlapping and convergence of at least four orogenies, older pre-Cambrian, late Jurassic, Laramide, and late (?) Miocene accompanied by igneous and metallization phenomena.

In the area south of Tucson, flat thrusts are known or inferred at Mineral Hill-Pima, Helvetia, and Bisbee. In these camps, however, the ores appear to be locally genetically related to high-angle normal (master) faults. Widespread oligoclase granite is associated with the camps from San Manuel to Helvetia.

The attempt to relate the orogenic belts, especially their intersections or coalescings, must explain the fact that the major copper deposits vary in age from pre-Cambrian to possible post-Miocene.

A characteristic of the area is the predominance of northeast schistosity developed during the pre-Cambrian orogeny. This is associated with metal-bearing northeast fracturing and faulting that persisted up to late geologic time. The especially intense pre-Cambrian disturbance of the crust may have regionally localized metallization, especially copper. From then on the metals persistently leaked through the reoccurring northeast cracks when reactivated by orogeny and igneous activity. **5817P8.**

Geology of Titanium

Joint Session with Society of Economic Geologists and Industrial Minerals Division

9:00 am Tuesday, February 18 Georgian Room

Wm. H. Gallaghan (Geol) and Meredith Johnson (SEG), *Chairmen*

Lac Tio Ilmenite Deposit by *E. O. Dearden*—The Lac Tio ilmenite deposit is located 25 miles north of Havre St. Pierre on the north shore of the St. Lawrence River. It is one of several similar deposits lying in the southeastern portion of one of the large pre-Cambrian anorthosite masses which occur locally throughout the Grenville subprovince of Quebec. The Lac Tio orebody is a gently inclined, tabular body occupying an exposed areal extent of at lesat 140 acres. Diamond drilling, which was stopped at a depth of 300 ft, has outlined a deposit of more than 100,000,000 tons of ore.

Inclusions and horses of anorthosite within massive ilmenite, as well as zones of disseminated ilmenite, are exposed on the surface and have been encountered in drill holes and in mining operations. The lower grade disseminated material is continuous over a considerable portion of the eastern part of the orebody and commonly exhibits a banded nature to a degree suggesting a differentiated sheetlike mass.

Macroscopically, two types of ore occur—a compact, coarsely crystalline well consolidated ilmenite and a granular coarsely crystalline friable ilmenite. Polished sections of the ore reveal numerous oriented microscopic lamellae of hematite. This crystallographic intergrowth is the result of the unmixing of an originally homogeneous solid solution.

It is the writer's opinion that the ilmenite-hematite is an original constituent of the anorthosite magma, with the larger deposits of commercial ore representing a late segregation or concentration product during consolidation of the magma. **5818A4.**

The Titanium Sands of Southern New Jersey by *Frank J. Markewicz, Daniel G. Parrillo, and Meredith E. Johnson*—The possibility that titanium-bearing sands of commercial grade existed in the coastal plain of New Jersey was considered after thoughtful appraisal of the probable ancient drainage patterns of the Delaware and Millstone Rivers, and the presence of disseminated ilmenite in both pre-Cambrian gneisses and Triassic igneous rocks. A member

New Mexico shows no preferred localization of mining districts in shield, shelf, or geosynclinal environments. This also applies elsewhere in the western United States where orebodies and related intrusives are found in schists, gneisses, granites, foliated and nonfoliated eugeosynclinal assemblages, nonfoliated miogeosynclinal assemblages, sediments of other than geosynclinal nature, and in acid and intermediate volcanics. The common denominator of most western districts then would appear to be a dynamic structural situation where parts, or all, of the more or less classical sequence of folding, faulting, intrusion or brecciation, and mineralization can be recognized; extrusion and post-mineralization faulting are often evident. The history of repeated faulting infers the maintenance of openings in deeply penetrating, fundamental pumping systems, and it is suggested by the writers that the intrusives and eventually the metals found their way into such systems from deep within the crust or from the mantle. (Areas involved only in shallow thrusting commonly are barren of intrusives and metals.) Such fundamental control frequently gives rise to striking regional alignments of intrusives, mining districts and individual orebodies. Some examples of structural control and alignments, particularly in Arizona and New Mexico are discussed briefly. 5817P4.

Lineament Tectonics and Some Ore Districts of the Southwest by *Evans B. Mayo*—Of many factors related to localization of ore, only the geometrical are considered here, and further, only two dimensions. The structural map of southwestern United States seems to show a predominance of four directions—northeast, northwest, near-meridional, and near-equatorial. This condition, denied by some, has been recognized by other geologists for a long time.

Certain intersections of the structural directions have played important roles in the geologic history. They heem to have localized granitic intrusions and volcanic fields. Ore itself is much more restricted, yet the major ore districts show a preference for the structural intersections.

It is thought that the correlation of ore faci with intersections will improve as regional structure becomes better known, and as the third (depth) and particularly the fourth (time) dimensions become better understood. 5817P5.

Tectonic Control of Mineral Belts in the Southwestern Colorado Metallogenic Province by *John W. Gabelman*—The typical unit hydrothermal mineral district in southwestern Colorado is composed of a central pipelike body of pervasive hydrothermal alteration surrounded by incomplete and irregular zones containing different mineral assemblages. Whereas the mineral deposits are commonly obscure in the landscape, the central altered areas are outstanding as isolated brilliantly colored areas in a drab background and were plotted from oblique color aerial photographs. Most district alteration centers in southwestern Colorado have been plotted and about 5 pct have been ground checked. Descriptions of deposits were obtained from the literature. Strong similarities between widely scattered districts exclusive of the Uravan belt indicate a single metallogenic province. Grouping of mineral districts indicates the following types of mineral belts or clusters: 1) Parallel to or enclosing portions of north-northwest Eocene thrusts of the Elk and western Sawatch Ranges. 2) East-west belts crossing the western Sawatch Range, Elk Mountains, Gunnison Valley, and western San Juan Mountains. These probably represent pre-Cambrian or Permian fault zones. 3) A belt along the curved San Juan tectonic axis. 4) Circular belts or clusters on the rims of collapsed volcanic centers. 5) Clusters associated with laccolithic intrusions. Belts of felsic intrusives generally coincide with mineral belts, but are more extensive.

Mineral belts appear to occur under strong tectonic control, and tectonic intersections are indicated to be the dominant controlling feature by the decrease in mineralization intensity away from them. Individual districts are less rigidly controlled. Individual deposits are rigidly controlled by local structures. 5817P6.

Notes on Mineralized Breccia Pipes by *Reno H. Sales and Roland B. Mulchay*—The authors are of the belief that breccia pipes are very important as structures providing channelways for ascending mineralizing solutions derived at great depths from igneous sources. The resulting ore deposits may be in the well known mineralized pipes, or they may be of the disseminated ore type. In the mineralized pipe the ore minerals are deposited within the pipe boundaries as cementing material or as a replacement of the breccia filling. In the case of the disseminated deposit, the ore mineral is deposited in surrounding rocks from mineral solutions traversing the pipe structure.

The theory is advanced that breccia pipes are developed chiefly in the absence of important fissuring and above deep-seated igneous intrusive rocks. The authors discuss various types of breccia pipes of the staff of the New Jersey Geological Survey put these ideas to the test one day late in October 1956, and within a few hours had discovered near Colliers Mills, in western Ocean County, a deposit that was subsequently found to contain 5 pct of heavy minerals.

Investigation of this and adjacent areas was immediately undertaken and it is now known that thousands of acres in Ocean and Burlington Counties are underlain by sand containing 3 pct or more of heavy minerals, of which ilmenite and leucoxene constitute 65 to 85 pct, with a TiO_2 content of 52 to 58 pct.

Discussions of the factors which controlled deposition have been lively and have been shared by the engineers and geologists of a dozen companies that have evidenced an interest in the deposits. This paper tells of known exploration results and presents the author's ideas of the sequence of geologic events leading to formation of the deposits. 5818A5.

Titanium Sand Deposits in Australia and West Africa by *Louis Moyd*—An illustrated tour of titanium-bearing beach and dune placer deposits in Queensland and New South Wales in Australia and in Senegal, Gambia, Sierra Leone, and Liberia in West Africa. Colored slides and commentary cover occurrence and exploration, development, and beneficiation methods. 5818A6.

Sand Deposits of Titanium Minerals by *J. L. Gillson*—Commercial sand deposits of titanium minerals occur in deposits of fluvial and marine origin and extend in age from Cretaceous to recent. These deposits are of major commercial importance because the titanium mineral recovered is of high grade, they are easily mined, many of them are accessible to transportation, and the reserves of some are very large.

Historically, sand deposits on the beaches of the Malabar Coast on the Indian peninsula provided most of the ore for the manufacture of titanium oxide pigment in the United States from 1928 to World War II.

Shipping restrictions incident to the war led to the development of low grade titanium deposits in Florida, the concentration of which was facilitated by the invention of the Humphrey Spiral and improved equipment for electrostatic concentration away from silicate minerals.

Rutile needed in the manufacture of welding rods led to development of Australian beach deposits, later stimulated by development of the Kroll process for titanium metal manufacture.

Recent discovery of fossil placer deposits on the coastal plain in New Jersey, and in the Gluf embayment of Tennessee has added greatly to the reserves of sand deposits of titanium minerals.

Geologic processes of the concentration of heavy minerals are summarized, and the important deposits of the world are tabulated and described briefly. 5818A7.

Geophysics Subdivision

General Session

9:00 am Tuesday, February 18 West Room

B. F. Howell, Jr., and J. E. Riddell, *Chairmen*

Spontaneous Polarization Applied in Prospecting for Nonconductive Stibnite by *Sherwin F. Kelly*—The antimony sulfide, stibnite, is one of the rare sulfides which does not possess metallic conductivity for electricity, and was therefore thought not amenable to exploration by electrical methods. A field test was nevertheless conducted on the Annabella antimony property in Guatemala which showed correspondence between antimony veins and spontaneous polarization reactions. The property was then geophysically surveyed and the results used to assist in orienting an exploration campaign. It is believed that the spontaneous polarization reactions arise, not from the stibnite in the veins, but probably from disseminated sulfides such as pyrite in the immediately adjacent wall rocks. To the extent that this association is constant, and only to that extent, could the spontaneous polarization results be considered useful indicators for an exploration target. 5818A8.

Geophysical Case History of the Clearwater Deposit, New Brunswick, Canada by *H. W. Fleming and R. R. Brooks*—The Clearwater deposit, a small occurrence of massive sulfide mineralization enclosed in an envelope of disseminated sulfide mineralization, was discovered as a result of an aeroelectromagnetic survey in New Brunswick in 1955. Subsequently, additional flights were made over the deposit and various ground follow-up methods were employed to ascertain the nature of their response. All methods proved

to be capable of indicating the occurrence with varying degrees of precision.

This paper is a presentation and a discussion of the magnetic and electromagnetic data, both airborne and ground, and the self-potential data obtained over this deposit. **5818A9.**

Quantitative Aspects of Aeromagnetic Interpretation by *D. W. Smellie*—The use of elementary polar, dipolar, dike, contact, and fault models is illustrated by cases taken from aeromagnetic maps in various geomagnetic latitudes. The use of inflection points, anomaly asymmetry, and anomaly half-width in distinguishing between type of source is described. The affects of remanent magnetization are discussed briefly. **5818A10.**

Effect of Soil Contamination on Geochemical Prospecting in the Coeur d'Alene District, Idaho by *F. C. Canney*—Contamination is a hazard ever present in most geochemical surveys. It can interfere either by creating spurious anomalies or by raising the background to such a level that true anomalies are no longer easily detectable. In some areas, as was true in the Coeur d'Alene district, concern over possible smelter contamination hitherto has restricted the use of geochemical techniques.

The areal extent and magnitude of the contamination patterns surrounding the lead and zinc smelters in the Coeur d'Alene district were investigated by determining the lead and zinc content of profile soil samples collected from 46 sites mostly within a five-mile radius of the smelter. Many of these samples, especially those of surface and near-surface material, contain highly anomalous amounts of lead and zinc. Several different contaminating agencies have undoubtedly contributed metal to these samples, but it is believed that most of the contamination came from smelter fumes. The contamination pattern is erratic, however, both horizontally and vertically. This pattern may be due 1) uneven distribution of the contaminants by wind action, 2) differential erosion of the metal-rich surface layer, and 3) various degrees of soil permeability and porosity. Most of the zinc contamination is distributed through the upper 6 in. of the soil profile, whereas most of the lead contamination is limited to the upper 2 in.

Within the area studied, the degree of contamination below a depth of about 6 in. is not sufficiently great to interfere seriously with the use of geochemical techniques; but to provide a safety factor, a soil-sampling depth of 10 in. is recommended. **5818A13.**

Significance of Geochemical Distribution Trends in Soil by *D. H. Yardley*—Differences in the nickel and copper content of various soil size fractions demonstrate the importance of correct selection of particle size of test material for a soil sampling program. The distribution trend curves of till show that the amount of heavy metal increases with decreasing size to about 80 mesh, but remains constant for smaller particle sizes. A *channel flow-stagnation zone* concept of the movement of soil solutions is proposed to explain the failure of the metal content to increase with the increase of particle surface area available, and relates the geochemical distribution to the geologic history.

Similar tests of active stream sediments demonstrate that the heavy metal content increases in the smaller particle sizes roughly parallel to the free surface area available. The characteristic difference between the distribution trend curves of active stream sediments and till is explained by the channel flow concept and by the difference in their geologic histories.

An apparently anomalous increase in the heavy metal content of the coarser particle sizes is explained by a dominance of particles of mechanical origin in the coarser sizes and dominance of exchangeable ion in the smaller. **5818A13.**

New Exploration Techniques

9:00 am Thursday, February 20 Gold Ballroom

G. Edward Manager and Maurice E. Tripp, *Chairmen*

Geochemical Exploration for Total Heavy Metals with Aqueous Dithizone Solution by *Nalin R. Mukherjee*—Being susceptible to thermal and photochemical oxidation in organic solvent solution, the use of dithizone (diphenylthiocarbazone) as an indicator for the colorimetric determination of trace quantities of total heavy metals is handicapped to a certain extent in the field work of geochemical prospecting, because the oxidized dithizone (diphenylthiocarbodiazone) which is soluble in organic solvent but insoluble in aqueous solution, is not a colorimetric indicator.

Upon theoretical analysis of dithizone and oxidized dithizone structures, a number of reagents (such as p-phenylenediamine dihydrochloride, hydroquinone) was selected to inhibit the dithizone exploration is best done by combined surface and ground-water investigation.

Uranium is highly mobile hydrogeochemically. Solubility depends partly upon valence, and valence upon the type of weathering. Waters high in sodium bicarbonate or sulfuric acid are efficient solvents; nearly neutral waters (pH 7) are not. Oxidation potential is important. Water-loving vegetation may withdraw more than 99 pct of the uranium from water. Organic compounds, especially in muskeg or peat-bog environments, may complex the uranium and thereby reduce the readily determinable content. Ground water first discharged following rains may flush out stagnant water long in contact with uranium minerals and be high in uranium. The uranium content of water means little until such factors are correctly interpreted.

Concentrations in water range from background of 0.01 parts per billion to as much as 210,000 parts per billion drill-hole waters beneficiated by comminution of uranium minerals. **5820A9.**

New Exploration Techniques

2:00 pm Thursday, February 20 Gold Ballroom

H. E. Hawkes and S. H. Ward, *Chairmen*

The Trials and Tribulations of Launching a New Airborne Geophysical Method by *Hans Lundberg and John H. Ratcliffe*—The airborne gravity gradiometer has been tested over a wide variety of geological structures and ore deposits, since its inception less than two years ago. During that time, various methods of recording, transcribing, and presenting the data have been utilized. This paper decribes the evolution of the means whereby electronic signals emanating from the detecting unit may be translated into interpretable maps of a function of the gravity field. The geologic significance of several typical examples will be discussed. **5820P5.**

A Study of the Electrochemistry of Self-Potentials Associated With Sulfide Ore Bodies by *Motoaki Sato*—Review of the literature on self-potentials associated with sulfide ore bodies shows that the basic electrochemical processes remain poorly understood. An investigation now in progress at the University of Minnesota attempts to gain greater insight into the mechanism of self-potentials through three approaches: theoretical and experimental work with sulfide minerals in solutions of known chemical compositions, field investigations of natural solutions in mines, and model studies simulating natural conditions. The most important controlling factors appear to be the contrasts, between surface and depth, of oxidation potentials and pH of the surrounding solutions, the continuity of high electrical conductivity of the ore body, and the chemical nature of the constituent mineral. Preliminary experimental results suggest that within a restricted range of oxidation potential and pH corresponding to depth conditions, the last factor becomes insignificant and the sulfide mineral functions simply as an inert electrode when the second factor is satisfied. A tentative specific hypothesis is proposed concerning the basic electrochemical mechanism involved in the production of self-potentials by sulfide ore bodies. **5820P6.**

Induced Polarization Effects in Pyrite-Bearing Sandstones by *Lennart A. Anderson and George V. Keller*—A study was made of electrical-transient response in a group of sandstone core samples, some of which contained a measurable quantity of pyrite, to determine the degree of electrometallic polarization in the pyrite-bearing samples and its contributions to the total polarization effect as a means of separating nonpyritic and pyritic samples. Resistivity, porosity, and electrochemical measurements were also made and these data analyzed with respect to the polarization data. It was found that the average polarization in the pyrite samples exceeded that in the nonpyritic samples, but that a distinct separation of the two on the basis of the polarization effect could be observed only when the pyrite content approached 10 pct by volume. **5820P7.**

Airborne Radioactivity Surveying as a Geological Mapping Tool by *Robert B. Guillou*—The use of airborne radioactivity surveying as a geological mapping tool is being investigated by the U. S. Geological Survey. A study of radioactivity profiles obtained by using equipment and surveying methods developed in the search for deposits of radioactive minerals indicates that airborne radioactivity surveying can materially assist the field geologist in certain areas. This technique can be of definite value by determining litho logic continuity between outcrops in areas of low relief and residual soil, such as the Piedmont, but it has limitations in areas of moderate relief or where the surficial material is not residual soil.

zone oxidation. Although these reagents prolonged the life of dithizone solution, the answer to this oxidation problem was not entirely satisfactory. However, the idea of dissolving dithizone in certain types of aqueous buffer solution via the solvent in conjunction with pure solvent during the so-called titration for the determination of trace quantities of total heavy metals in geochemical prospecting samples (such as soil and water samples) were found to be successful.

The effect of the chosen reagents in the retardation of dithizone oxidation, and the preparation, properties, and uses of the aqueous dithizone solution will be discussed in detail in this paper. **5820A5.**

Rapid Field Methods for the Colorimetric Determination of Nickel for Use in Geochemical Prospecting by *Harold Bloom*—Dimethylglyoxime reacts with nickel in a buffered ammoniacalcitrate solution containing the detergent *Aquet* and hydroxylamine-hydrochloride. The resulting nickelous dimethylglyoxime is extracted in xylene which floats to surface. Readily soluble nickel is removed from rock, soil or sediments by digestion with 1:3 nitric acid. Visual comparison with standards permits the estimation of from 50 to 10,000 ppm Ni. About 70 determinations per man-day can be carried out.

With minor modifications to the above procedure, sediments and soils may be semi-quantitatively analyzed for nickel at the sample site. The chemical equipment is easily portable and the analysis extremely rapid because the buffer, dimethylglyoxime, and xylene are added simultaneously to the sample and no heating is required. The sensitivity varies with the availability of the nickel ions; under favorable conditions, one may obtain a positive test for as little as 10 μg in soils and sediments. Results of a field survey carried out at Gold Hill, Col., are presented. **5820A6.**

Camp and Sample-Site Determination of Traces of Mercury in Soils and Rocks by *F. N. Ward and E. H. Bailey*—Camp-site and sample-site methods for determining from about 0.5 to 16 ppm of mercury in soils and rocks have been devised to complement the analytical methods already widely used in geochemical prospecting. In both procedures the sample solution is obtained by a short digestion of the finely powdered sample with hot nine-molar sulfuric acid and bromine, the latter generated in place. In the camp-site procedure, the sample solution is buffered at a pH of four prior to the estimation, which is made by comparing the colors of standard solutions with the color of the mercuric dithizonate extracted from a sample solution into a relatively small volume of an organic solvent. Estimation by the sample-site method is made by titrating a fixed amount of dithizone with the sample solution—the volume of the latter being inversely proportional to the mercury content of the sample. Except for the establishment of standards, the time required by an experienced analyst seldom exceeds 10 min for a camp-site determination and 5 min for a sample-site determination. Camp-site determinations, differing also from the sample-site determinations by their greater specificity and sensitivity, are useful for commodity studies and intensive exploration programs. Sample-site determinations are useful in extensive and reconnaissance-type programs. The results obtained on samples taken along traverses across known mercury mineralization in west central California and western Nevada demonstrate the usefulness of both methods in geochemical prospecting. **5820A7.**

A Nuclear Detector for Beryllium Minerals by *T. Cantwell, H. E. Hawkes, and N. C. Rasmussen*—A Semi-quantitative method of determining the beryllium content of crushed mineral samples has been experimentally developed and given a preliminary test with standard laboratory equipment. The method depends on the following nuclear reaction, which is relatively selective for beryllium

$$ {}_4Be^9 + {}_2He^4 \text{ (}\alpha\text{ particle)} \longrightarrow {}_6C^{12} + {}_0n^1 \text{ (neutron)} $$

An α-particle source consisting of approximately 20 millicuries of polonium is placed next to the powdered sample. The resulting fast neutrons are moderated in paraffin and then counted in a standard boron trifluoride counter. The number of counts is directly proportional to the amount of beryllium, and to a lesser extent boron and fluorine, exposed at the surface of the sample. **5820A8.**

Hydrogeochemical Exploration for Uranium by *Philip F. Fix*—Hydrogeochemical exploration for uranium appraises possibilities by samples of water, water-borne sediment, and water-loving vegetation, and is most effective in humid and semi-arid climates. Rapid exploration of large areas is best done by semi-quantitative, surface-water sampling; the ground-water method is potentially quantitative, but most useful under special conditions. Intensive

In an area of Triassic rocks near Bealeton, Va., it is possible to differentiate between diabase and sedimentary rocks on the basis of radioactivity and a map of radioactivity units prepared from the data correlates with the areal geology. Radioactivity units are well defined in an area of the crystalline Piedmont near Richmond, Va., and furnish an excellent guide for field mapping. Present investigations include study directed toward determining whether changes in surveying technique or modifications in equipment will produce data of more use as an aid in areal geologic mapping. **5820F8.**

Meteorological Influence on Radon Concentration in Drill Holes by *Allan B. Tanner*—The concentration or radon^{222} in drill holes in uraniferous limestone near Grants, N. M., was observed to change markedly with different meteorological conditions. Continuous records of wind velocity, surface temperature, and barometric pressure were obtained for a 20-day period during which a series of analyses was made for the radon content of air collected at several depths in a 4-in.-diam drill hole. Less intensive investigations were made of several other drill holes.

An inverse correlation was noted between trends in barometric pressure and both the total amount and the maximum concentration of radon in a hole. Pressure changes of about 10 mm of mercury over a period of a day or more resulted in approximately twofold changes in the total amount of radon in the hole. The relation is believed to be a manifestation of *earth breathing*.

The effects of wind differed greatly for different holes: no significant effect was observed when a 15 to 16-mph wind blew over an open hole for 4 hr; a 20 to 30-mph wind, blowing over another open hole of the same diameter and depth for 6 hr, caused a reduction in the total amount of radon in the hole by a factor of about 400. No correlation was noted between surface temperature and the behavior of radon in the drill holes. **5820F9.**

Solid Phosphor Core Scanner for Determining Radiation in Drill Core Samples by *W. W. Vaughn, R. H. Barnett, and E. E. Wilson*—An instrument that will scan a moving train of drill core for radioactivity has been constructed and tested. The instrument will accept drill core from 1 to 3 in. diam by way of a continuous conveyor belt and will provide a permanent record of radioactivity as a function of drill core length. Use of chemically assayed samples containing uranium in equilibrium with the decay products makes possible a calibration curve whereby the equivalent uranium content of an unknown sample may be determined. The counting chamber has essentially three geometry and is shielded by lead walls 2 in. thick. Four sodium iodide (NaI) crystals 2 in. diam by 2 in. thick and four photomultiplier tubes are used for the detecting elements. Although the core scanner was designed primarily to measure radioactivity in a continuous moving train of drill core, it may be used with equal effectiveness when properly calibrated to analyze crushed sample material in cylindrical cardboard containers. The sensitivity of the instrument is such that a variation in uranium content of 0.01 pct will give a corresponding change of 50 counts per sec in the recorded counting rate. Semi-quantitative results may be taken with sample material ranging as low as 0.005 pct U. **5820F10.**

Society of Economic Geologists

SEG is holding two joint sessions with SME Divisions—Industrial Minerals and Geology Subdivision. Abstracts are given under Geology, page 53.

Copper Mineralization and Regional Structure In Arizona, New Mexico, and Sonora

2:30 pm Monday, February 17 West Room

W. C. Lacy (Geol) and K. Cochran (SEG), *Chairmen*

Geology of Titanium

9:00 am Tuesday, February 18 Georgian Room

Wm. H. Callaghan (Geol) and Meredith Johnson (SEG), *Chairmen*

Program of the Society of Mining Engineers

AIME Annual Meeting, February 16 to 20, 1958, New York

Headquarters for the SME sessions and social functions during the AIME Annual Meeting will be the Statler Hotel. In the program, the following abbreviations indicate Divisional or other organizational sessions: *Coal*, Coal Division; *EMD*, Extractive Metallurgy Division of The Metallurgical Society of AIME; *IndMD*, Industrial Minerals Division; *ISD*, Iron and Steel Division of The Metallurgical Society of AIME; *MBD*, Minerals Beneficiation Division; *MGGD*, Mining, Geology, and Geophysics Division; *Min*, Mining Subdivision; *Geol*, Geology Subdivision; *Geoph*, Geophysics Subdivision; and *SEG*, Society of Economic Geologists, which is holding joint sessions with SME Divisions. The Mineral Economics sessions are sponsored by the Council of Economics of AIME.

Papers for which preprints are available are listed by number on page 113. These may be obtained only by mailing in SME coupon properly filled out.

MONDAY, FEBRUARY 17, AM

Min — **Open Pit Mining**

9:30 am — Georgian Room

W. J. Rundle, *Chairman*

The Pima Open Pit and Haulage Facilities: *Robert Thurmond*, Pima Mining Co. **5817A1**

Mining of Magnetite and Martite at Benson Mine: *Arthur F. Peterson, Jr., and Wm. P. Bach*, Jones & Laughlin Steel Corp. **5817A2**

Estimating Data for Haulage Trucks—Open Pit Mines: *Howard Wilmeth*, Kennecott Copper Corp. **5817A3**

Geol — **Selected Geologic Topics**

9:30 am — West Room

T. N. Walthier and Charles Meyer, *Chairmen*

Intrusions and Ore Deposition in New Mexico: *Charles Belt, Jr.*, Columbia University. **5817A5**

Some Considerations in Determining the Origin of Ore Deposits of the Mississippi Valley Type: *E. L. Ohle*, Copper Range Co. **5817A6**

Inferred Assemblages of Mineral Phases in the System Cu-Fe-As-S: *Hugh McKinstry*, Harvard Univ. **5817A7**

Hydrologic Factors That Affect Water Control in the Zinc-Lead Mines of Southwest Wisconsin: *Charles L. R. Holt*, U. S. Geological Survey. **5817A21**

Grouting and Water Control in the Kentucky-Illinois Fluorspar Area: *Fred C. Wrobbel*, Aluminum Co. of America. **5817A23**

Minerals for Newer Ceramic Applications: *Edward J. Smoke and John H. Koenig*, Rutgers University. **5817A22**

MONDAY, FEBRUARY 17, PM

Min — **Safety and Health**

2:30 pm — Ivy Suite

J. M. Ehrhorn and M. R. Romney, *Chairmen*

Preplanning Safety in the Uranium Mining Industry: *John E. Bailey*, National Lead Co. **5817P1**

Increase Safety, Better Production, Through Use of Communication and Electronic Equipment: *Earl A. Berry*, Mine Safety Appliances Co. **5817P2**

Symposium on Safety and Health: *James Westfield*, U. S. Bureau of Mines; *John A. Johnson*, U. S. Bureau of Mines; *Henry N. Doyle*, U. S. Dept. of Health; Education, and Welfare; *and Miles P. Romney*, Utah Mining Assn. **5817P3**

Sulfide Systems as Geological Thermometers: *Gunnar Kullerud*, Carnegie Institution of Washington. **5817A8**

Time Aspects of Geothermometry: *R. J. P. Lyon*, Kennecott Copper Corp. **5817A9**

MBD Crushing and Grinding

9:30 am — Penn Top South

Bunting Crocker and Frank Windolph, *Chairmen*

Ball Mill Performance at Super Critical Speeds: *R. T. Hukki*, Finland Institute of Technology. **5817A10**

A Study of Different Types of Steel for Grinding Media at Climax: *F. Windolph*, Climax Molybdenum Corp., *and E. J. Duggan*, Climax Uranium Co. **5817A11**

Single-Stage vs Two-Stage Grinding at Homestake: *C. E. Schmidt and F. M. Howell, Jr.*, Homestake Mining Co. **5817A12**

Pebble Milling at Faraday Uranium Mines: *R. J. Roach*, Faraday Uranium Mines Ltd. **5817A13**

A Study of Grinding Ball Wear Employing Radioactive Tracers: *A. L. Wesner, M. Pobereskin, and J. E. Campbell*, Battelle Memorial Institute. **5817A13a**

Coal Bump Symposium

9:30 am — Penn Top North

G. R. Spindler and E. Minor Pace, *Chairmen*

Activity of the Bureau of Mines in Bump Investigations and Research: *Edward Thomas* (Roof Control) U. S. Bureau of Mines. **5817A14**

Ground Stress Investigations in Canadian Coal Mines: *A. Brown*, Dept. of Mines and Technical Surveys, Canada. **5817A15**

The Occurrence of Mountain Bumps at the Sunnyside, Utah, Mines of the Kaiser Steel Corp.: *John Peperakis*, Kaiser Steel Corp. **5817A16**

Progress in the Control of Mountain Bumps in the Pocahontas No. 4 Seam: *Woods G. Talman and John L. Schroder, Jr.*, U. S. Steel Corp. **5817A17**

Coal Mine Bumps Can Be Eliminated: *H. E. Mauck*, Olga Coal Co. **5817A18**

Causes and Control of Coal Mine Bumps: *Charles T. Holland*, Virginia Polytechnic Institute. **5817A19**

IndMD Mine Hydrology

9:30 am — Washington Room

W. T. Stuart and Frank Hunter, *Chairmen*

Some Notes on the Principles of Mine Hydrology: *H. E. LeGrand*, Consulting Geologist. **5817A20**

Geol-Seg Copper Mineralization And Regional Structure in Arizona New Mexico, and Sonora

2:30 pm — West Room

W. C. Lacy, AIME, and K. Cochran, SEG, *Chairmen*

Relation of Western Mining Districts to Regional Tectonics, with Special Reference to Southern Arizona and Southwestern New Mexico: *S. E. Jerome and D. R. Cook*, Bear Creek Mining Co. **5817P4**

Tectonic Control of Mineral Belts in the Southwestern Colorado Metallogenic Province: *John W. Gabelman*, U. S. Atomic Energy Commission. **5817P6**

Notes on Mineralized Breccia Pipes: *Reno Sales and Roland Mulchay*, The Anaconda Co. **5817P7**

The Origin of the Southwest Metallogenic Province: Lineament Tectonics and Some Ore Deposits of the Southwest: *Evans B. Mayo*, University of Arizona. **5817P5**

MBD Concentration

2:30 pm — Penn Top South

S. E. Erickson and R. H. Lowe, *Chairmen*

Relation of Magnetic Susceptibility to Mineral Composition: *E. M. Spokes*, University of Kentucky, *and D. R. Mitchell*, Pennsylvania State University. **5817P9**

The Metallurgical Story at Inspiration: *C. B. Kettering and K. L. Power*, Inspiration Consolidated Copper Co. **5817P10**

Trends in Uranium Milling: *R. H. Kennedy*, U. S. Atomic Energy Commission. **5817P11**

Collector Mixtures and Collector Frother Emulsions in Sulfide Flotation: *Arvid E. Anderson*, Bethlehem Cornwall Corp. **5817P12**

Coal Coal Preparation

2:30 pm — Penn Top North

Paul L. Richards and Harry Washburn, *Chairmen*

The Moss No. 2 Preparation Plant: *Richard Joslin*, Clinchfield Coal Co. **5817P12a**

Coal Preparation at the Humphrey Mine: *Victor Phillips*, Christopher Coal Co. **5817P13**

Application of Mineral Dressing Fundamentals to the Solution of the Fine Coal Problem: *M. C. Chang and John Dasher*, Crucible Steel Co. of America. **5817P14**

Cleaning of Fine Coals by Convertol Process: *S. C. Sun*, Pennsylvania State University, *and W. L. McMorris, III*, Columbia & Geneva Coal Mine. **5817P15**

IndMD-MBD

General Industrial Minerals

2:00 pm — Sky Top Room

G. W. Josephson and Norman Sather, *Chairmen*

New Concepts of Bulk Solids Lifting by Bucket Elevator: *C. R. Davis*, Chain Belt Co. **5817P16**

A Critical Study of Thickening: *A. M. Gaudin, M. C. Fuerstenau, and S. R. Mitchell*, Massachusetts Institute of Technology. **5817P18**

Use of Jigs on the Sand and Gravel Industry: *John Meckenstock*, Meckum Engineering Inc. **5817P19**

The Application of Horizontal-Type Filters to the Metallurgical Industries: *W. F. White*, Bird Machine Co. **5817P20**

Mineral Economics Session

2:00 pm — Georgian Room

P. D. Wilson and Evan Just, *Chairmen*

General Economics: *Charles Broderick*, Lehman Bros. **5817P21**

International Marketing: *J. Vuillequez*, American Metal Co. Ltd. **5817P22**

Copper Prospects: *Jos. Zimmerman*, Daily Metal Reporter. **5817P23**

Economic Evaluation of an Industrial Mineral Project: *J. E. Castle*, International Minerals & Chemical Corp. **5817P24**

Current Development in Gravel Beneficiation: *W. L. Price*, Dravo Corp. **5817P25**

TUESDAY, FEBRUARY 18, AM

Min — General Mining

9:00 am — Ivy Suite

Hugh J. Leach, *Chairman*

Panel Discussion on Use of Ammonium Nitrate Fertilizer for Blasting. **5818A1**

a) *Charles Grant*, Jones & Laughlin Steel Corp.
b) *A. C. Bigley*, Western Mining Operations
c) *Lewis J. Patterson*, U. S. Steel Corp.
d) *Walter M. Chapman*, National Lead Co.

MBD

Theory of Concentration Processes

10:00 am — Sky Top

E. W. Giesecke and M. E. Wadsworth, *Chairmen*

Mechanism of Flocculent Adsorption on Clay Minerals: *M. E. Wadsworth and A. S. Peck*, University of Utah. **5818A14**

Solubility of Some Metal Ethyl Xanthates: *P. S. M. van Heteren*, Leiden University, The Netherlands, *and P. L. DeBruyn*, Massachusetts Institute of Technology. **5818A15**

Effect of Iron Oxide Slime Coatings on Silica Flotation: *A. M. Gaudin and M. L. Miaw*, Massachusetts Institute of Technology. **5818A21**

Correlation of Contact Angle, Adsorption Density, Zeta Potential, and Flotation Rate: *D. W. Fuerstenau*, Electro Metallurgical Co. **5818A17**

Activation and Deactivation Studies with Copper on Sphalerite: *A. M. Gaudin, G. W. Mao*, Massachusetts Institute of Technology, *and D. W. Fuerstenau*, Electro Metallurgical Co. **5818A16**

Coal

Fluidized Thermal Drying of Fine Coal

9:00 am — Penn Top North

D. A. Dahlstrom and F. M. Stephens, *Chairmen*

Experience with The FluoSolids Fine Coal Dryer: *M. W. Brandt*, Dorr-Oliver Inc. **5818A18**

Fluidization—A Practical Approach to Thermal Drying of Fine Coal: *J. P. Blair and Fred Coward, Jr.*, Heyl & Patterson Inc. **5818A19**

The Parry Dryer: *R. J. Lofquist*, Consultant, *and James C. Wright*, Silver Engineering Works. **5818A20**

TUESDAY, FEBRUARY 18, PM

Coal — Division Luncheon

12:00 noon — Penn Top Center

Speaker: *Richard L. Bowditch*, chairman of the board, C. H. Spragg & Co., Boston, Mass.

IndMD — Luncheon

12:30 pm — Georgian Room

AIME — All-Institute Session

2:30 pm — Grand Ballroom

(No Division or Subdivision Meetings scheduled)

SME — Cocktails

6:00 pm — Georgian Foyer

Panel on Use of Conveyor Belts in Underground Metal Mines. **5818A2**

a) Conveyor Belts at Miami Copper Co.: *Benjamin R. Coil and James B. Fletcher*, Miami Copper Co.

b) Underground Conveyor Experience at Inland's Iron Mines: *Howard M. Graff and James R. Gronseth*, Inland Steel Co.

Raising by Use of a Cage: *John C. Wangaard*, Pickands Mather & Co. **5818A3**

Geol-Seg-IndMD
Geology of Titanium

9:00 am — Georgian Room

Wm. H. Callaghan, AIME, and Meredith Johnson, SEG, *Chairmen*

Lac Tio Ilmenite Deposit: *E. O. Dearden*, Kennco Explorations Ltd., Canada. **5818A4**

Sand Deposits of Titanium Minerals: *J. L. Gillson*, E. I. du Pont de Nemours & Co. **5818A7**

Exploration Methods and Evaluation of Sand-Type Deposits: *Frank McKinley*, Humphrey's Gold Corp. **5818A7a.**

The Titanium Sands of Southern New Jersey: *Frank J. Markewicz, Daniel G. Parrillo, and Meredith E. Johnson*, N. J. Geological Survey. **5818A5**

Titanium Sand Deposits in Australia and West Africa: *Louis Moyd*, Consulting Geologist. **5818A6**

Geoph — General Session

9:00 am — West Room

B. F. Howell, Jr., and J. E. Riddell, *Chairmen*

Spontaneous Polarization Applied in Prospecting for Nonconductive Stibnite: *Sherwin F. Kelly*, Kelly Geophysical Services. **5818A8**

Geophysical Case History of the Clearwater Deposit, New Brunswick, Canada: *H. W. Fleming and R. R. Brooks*, Kennco Explorations Ltd., Canada. **5818A9**

Quantitative Aspects of Aeromagnetic Interpretation: *D. W. Smellie*, Consulting Geophysicist. **5818A10**

Defining Mineral Potential Areas through Airborne Geophysical Surveys: *W. George Wahl*, Consultant, Geology and Geophysics. **5818A11**

Effect of Soil Contamination on Geochemical Prospecting in the Coeur d'Alene District, Idaho: *F. C. Canney*, U. S. Geological Survey. **5818A12**

Significance of Geochemical Distribution Trends In Soil: *D. H. Yardley*, University of Minnesota. **5818A13**

Overvoltage Developments and Geophysical Application by Newmont Exploration Ltd., 1946-1955: *R. W. Baldwin*, Newmont Exploration Ltd.; *W. E. Bell*, Varian Assoc.; *A. A. Brant*, Newmont Exploration Ltd.; *L. S. Collett*, Geological Survey of Canada; *A. W. Love*, Wylie Electronics; *K. A. Ruddock*, Varian Assoc.; *H. O. Seigel*, Consultant; *and J. R. Wait*, National Bureau of Standards. **5818A11**

Society of Mining Engineers Dinner

7:00 pm — Georgian Room

Toastmaster: *Elmer A. Jones*, SME President

Speaker: *Leo Wolman*, Columbia University

AIME — Informal Dance

9:00 pm — Grand Ballroom

WEDNESDAY, FEBRUARY 19, AM

MGGD
Some Economic Considerations in Exploration Geology

9:00 am — Georgian Room

James O. Harder and Edward L. Tullis, *Chairmen*

Some Legal Problems Encountered in the Acquisition of New Mineral Property: *R. E. Driscoll, Jr.*, Homestake Mining Co. **5819A1**

The Exploration Geologist's Work in Acquisition of Mineral Properties: *M. W. Cox*, Wisser & Cox. **5819A2**

Economics of Geologic Exploration: *Donald M. Davidson*, E. J. Longyear Co. **5819A3**

Valuation of a Mineral Deposit: *A. L. Slaughter*, Homestake Mining Co. **5819A4**

Mineral Economics Session

9:00 am — Ivy Suite

J. L. Kimberley and Alvin Knoerr, *Chairmen*

An Exciting Future Ahead with Lead—An Industry Program: *R. L. Ziegfeld*, Lead Industries Assn. **5819A8**

Free World Demand and Supply of Chrome Ore: *J. M. Warde*, Union Carbide Ore Co. **5819A5**

Chemical Fuels and Other Organometallic Compounds —Their Impact on the Mineral Industry: *Donald Gibbons*, A. D. Little & Co. **5819A6**

Recent Developments in the Allowances for Percentage Depletion: *Frank H. Madison*, Behre Dolbear & Co. **5819A7**

MBD — Mill Design

9:00 am — Sky Top

Harry L. McNeill and Charles N. Bailey, *Chairmen*

Comparison of 2400 and 4160 Volt Distribution Systems for Concentrators: *R. M. Wilson* **5819A9**

Earthquake Design for Metallurgical Plants: *W. B. Hester*, Stearns-Roger Manufacturing Co. **5819A10**

Tailings Line Design as Affected by pH: *A. A. Wallach*, Kaiser Engineers. **5819A11**

Factors in the Selection of Motors and Speed Reducers for Conveyor Drives: *Clark B. Risler*, Westinghouse Electric Corp. **5819A12**

Coal — Technical Session

9:00 am — Penn Top North

E. M. Spokes and J. Allen Brookes, *Chairmen*

Coal Mine Personnel Selection: *C. R. Nailler*, Christopher Coal Co. **5819A13**

Meeting the Challenge of Mining in Thirty Degree Pitching Coal Seams: *Albert M. Keenan and Andrew Allan*, Thompson Creek Coal & Coke. **5819A14**

The Application of Industrial Engineering in Coal Mining: *Charles W. Rountree, Jr.*, Island Creek Coal Co. **5819A15**

IndMD — Uranium, Thorium, and Beryllium

9:00 am — Penn Top South

Pauline Moyd and P. L. Merritt, *Chairmen*

New Trends in Uranium Geology: *Donald L. Everhart*, U. S. Atomic Energy Commission. **5819A16**

Geology of the Uranium Deposits in the Ambrosia Lake-Jackpile Area, New Mexico: *L. S. Hilpert and A. F. Corey*, U. S. Geological Survey. **5819A17**

Commercial Thorium Ores: *H. E. Kremers*, Lindsay Chemical Co. **5819A18**

Beryllium Raw Material Supply as It Affects Growth of the Industry: *S. A. Feitler*, U. S. Bureau of Mines. **5819A19**

WEDNESDAY, FEBRUARY 19, PM

MGGD — Division Luncheon

12:00 noon — Grand Ballroom

Council of Economics of AIME Luncheon and Business Meeting

12:15 pm — West Room

MGGD — Jackling Lecture

2:00 pm — Grand Ballroom

Planning for Deep Mining at Homestake: *A. H. Shoemaker*, Homestake Mining Co.

THURSDAY, FEBRUARY 20, AM

Min — General Mining

9:00 am — Georgian Room

George W. Wunder, *Chairman*

Mining Research in Europe: *Leonard Obert*, U. S. Bureau of Mines. **5820A1**

Statistical Method of Calculating and Analyzing Ore Reserves: *John A. Patterson*, U. S. Atomic Energy Commission. **5820A2**

Blasting Vibrations—Cause and Effect: *Lewis D. Leet*, Harvard University. **5820A3**

Fundamental Studies of Percussion Drilling: *Howard L. Hartman*, Pennsylvania State University. **5820A4**

Geoph — New Exploration Techniques

9:00 am — Gold Ballroom

G. Edward Manager and Maurice E. Tripp, *Chairmen*

Geochemical Exploration for Total Heavy Metals with Aqueous Dithizone Solution: *N. R. Mukherjee*, University of Alaska. **5820A5**

Rapid Field Methods for the Colorimetric Determination of Nickel for Use in Geochemical Prospecting: *Harold Bloom*, Colorado School of Mines. **5820A6**

Camp and Sample-Site Determination of Traces of Mercury in Soils and Rocks: *F. N. Ward and E. H. Bailey*, U. S. Geological Survey. **5820A7**

A Nuclear Detector for Beryllium Minerals: *T. Cantwell, N. C. Rasmussen*, Massachusetts Institute of Technology, *and H. E. Hawkes*, University of California. **5820A8**

A Field Test for Readily Soluble Copper in Soils and Alluvium: *R. H. C. Holman*, Geological Survey of Canada. **5820A10**

MBD-ISD — Pyrolysis and Agglomeration

9:00 am — Sky Top

F. D. DeVaney and R. L. Stephenson, *Chairmen*

FluoSolids Roasting of Sulfides for Recovery of Copper, Iron, and Sulfur: *H. Kurushima*, Dowa Mining Co., Japan, *and R. M. Foley*, Dorr-Oliver Inc. **5820A11**

Beneficiation of Low Grade Iron Ores Involving Direct Reduction: *Alex Stewart*, National Lead Co., *and H. K. Work*, New York University. **5820A12**

MBD Magnetic Separation

A Symposium on Recent Trends in Equipment and Applications

2:00 pm — Sky Top

Earl Herkenhoff and Larry Roe, *Chairmen*

Magnetic Separation of Ores—History and New Foreign Developments: *L. A. Roe,* International Minerals & Chemical Corp. **5819P1**

Dry Magnetic Cobbing Separations: *Wm. M. Aubrey,* Bethlehem Steel Corp. **5819P2**

Wet Magnetic Separators in Taconite Plants: *Luther G. Hendrickson,* U. S. Steel Corp. **5819P3**

Magnetic Separators in the Heavy Media Process: *K. E. Merklin,* Pickands Mather & Co. **5819P4**

Coal Technical Session

2:00 pm — Penn Top North

Jesse F. Core and C. L. Sarff, *Chairmen*

Benefits Which Derive From the Use of A. C. Power Underground: *C. S. Conrad,* Consolidation Coal Co. **5819P5**

Continuous Coke Production on a Water-Cooled Grate Stoker: *R. J. Grace,* Bituminous Coal Research Inc., *and Jos. D. Doherty,* Island Creek Coal Sales Co. **5819P6**

Pioneering Carrier Communications and Control in Mines and Mills: *W. Porter Place,* Femco Inc. **5819P7**

A Comparison of Installation and Operating Costs of Automatic Skip Hoisting vs Belt Slope for Deep Coal Seams: *R. R. Richart,* Freeman Coal Mining Corp. **5819P8**

IndMD General Industrial Minerals

2:00 pm — Penn Top South

Ray Shrode and Richard M. Foose, *Chairmen*

Underground Movement and Subsidence over the U. S. Potash Co. Mine, Div. of U. S. Borax and Chemical Corp., Carlsbad, New Mexico: *E. H. Miller and F. L. Pierson,* U. S. Potash Co. **5819P9**

Boron—Its Past, Present, and Future: *D. S. Dinsmoor and Frank Weishauph,* American Potash & Chemical Corp. **5819P10**

Removal of Heat in Cement Grinding: *J. R. Tonry,* Portland Cement Assoc. **5817P17**

Uses of Standard Ottawa Testing Sands: *Paul A. Gerding,* Ottawa Silica Co. **5819P11**

Utilization of Pennsylvania Slate for Expanded Aggregate: *Frank D. Hoyt,* Pennsylvania State University. **5819P12**

Beneficiation of Iron Ores High in Phosphorus and Sulfur: *Alex Stewart, Geo. Reed, Jr.,* National Lead Co., Inc., *and P. Herasymenko,* New York University. **5820A22**

Reduction of High-Grade Port Henry Magnetite Concentrates: *Earle C. Smith and D. E. Babcock,* Republic Steel Corp. **5820A13**

Recovery of Iron Ores Containing Titanium, Manganese, Chromium, and Alkali Metal Sulfates: *A. G. Oppegaard, O. Moklebust, and G. G. Reed, Jr.,* National Lead Co., Inc. **5820A14**

MBD-EMD Solution and Precipitation

9:00 am — Penn Top South

A. L. Wesner and John Dasher, *Chairmen*

Resin-in-Pulp Process at Mines Development Inc.: *H. D. Webb, G. F. Richards, and G. T. Bator,* Mines Development Inc. **5820A15**

Climax Uranium Co.'s Approach to Vanadium Recovery by Solvent Extraction: *R. E. Musgrove, E. E. Maurer, and R. E. Fischer,* Climax Uranium Co. **5820A16**

Amine Extraction of Port Radium Leach Liquor: *M. E. Grimes,* Eldorado Mining & Refining Ltd. **5820A17**

New Solvent Extraction Techniques for Uranium Purification: *R. S. Long, J. E. Magner, and D. A. Ellis,* The Dow Chemical Co. **5820A18**

Coal Technical Session

9:00 am — Penn Top North

J. B. Benson and C. M. Donahue, *Chairmen*

Safety Features in the Design and Development of Ireland Mine: *Geo. W. McCaa,* Hanna Coal Co. **5820A19**

Auxiliary Ventilation of Continuous Miner Places: *R. W. Stahl,* U. S. Bureau of Mines. **5820A20**

Planning and Programming for Coal Mine Safety: *Charles Ferguson,* United Mine Workers of America. **5820A21**

THURSDAY, FEBRUARY 20, PM

Min Canadian-Latin American Session

2:00 pm — Georgian Room

John W. Chandler and J. D. Bryce, *Chairmen*

The Bicroft Uranium Mines Operation: *J. D. Bryce*

and J. M. Thompson, Bicroft Uranium Mines Ltd. **5820P1**

Open Pit Mining Operations, Knob Lake, Canada: *A. E. Moss*, Iron Ore Co. of Canada. **5820P2**

Mining at Eagle-Picher's Esmeralda Unit, Parrale, Mexico: *R. B. Taylor*, Eagle Picher de Mexico. **5820P3**

The Moa Bay-Port Nickel Project—New U. S. Nickel and Cobalt from Cuban Ores: *Forbes K. Wilson*, Freeport Sulphur Co. **5820P4**

Geoph
New Exploration Techniques

2:00 pm — Gold Ballroom

H. E. Hawkes and S. H. Ward, *Chairmen*

The Trials and Tribulations of Launching a New Airborne Geophysical Method: *Hans Lundberg and J. H. Ratcliffe*, Lundberg Exploration Ltd. **5820P5**

A Study of the Electrochemistry of Self-Potentials Associated with Sulfide Ore Bodies: *Motoaki Sato*, University of Minnesota. **5820P6**

Induced Polarization Effects in Pyrite-Bearing Sandstones: *Lennart A. Anderson and Geo. V. Keller*, U. S. Geological Survey. **5820P7**

Airborne Radioactivity Surveying as a Geological Mapping Tool: *Robert B. Guillou*, U. S. Geological Survey. **5820P8**

Meteorological Influence on Radon Concentration in Drill Holes: *Allan B. Tanner*, U. S. Geological Survey. **5820P9**

Solid Phosphor Core Scanner for Determining Radiation in Drill Core Samples: *W. W. Vaughn, R. H. Barnett, and E. E. Wilson*, U. S. Geological Survey. **5820P10**

Open Forum on New Geophysical and Geochemical Exploration Techniques: *H. E. Hawkes*, University of California, *and S. H. Ward*, Nucom Ltd., Canada. **5820P11**

MBD
Developments in Operating Control

2:00 pm — Sky Top

H. E. Uhland and J. W. Snavely, *Chairmen*

The Development of a Continuous BPL Analyzer. *H. B. Graves, Jr., and Elliott Northcott*, International Minerals & Chemical Corp. **5820P12**

Automatic Weighing and Ratioing of Solids: *Thomas L. Mell*, Trans-Weigh Co. **5820P13**

Developments in Continuous Weighing of Bulk Solids: *T. P. Goslin* **5820P14**

Hydraulic Solids Flowmetering: *E. J. Klein and E. F. Nagle*, Minneapolis-Honeywell Re. **5820P15**

Gamma Ray Gages in Beneficiation Plants: *John R. Riede*, Ramsey Engineering Co. **5820P16**

Coal
Technical Session

2:00 pm — Penn Top North

Henry J. Hager and James D. Reilly, *Chairmen*

Permissible Dust Counter for Use in Coal Mines: *Sabert Oglesby*, Southern Research Institute. **5820P17**

Bonding Experiments on Bituminous Coal Mine Roof Strata: *E. R. Maize*, U. S. Dept. of Interior. **5820P18**

Roof Bolting in Kentucky Coal Mines: *George K. Martin*, University of Kentucky. **5820P19**

Handling Air from Conventional Coal Dryers: *M. I. Dorfan and Raymond Mancha*, Joy Manufacturing Co. **5820P20**

EMD-MBD
Symposium: Thickening, Filtration, and Flocculation

2:00 pm — Penn Top South

A. H. Ross and F. T. Davis, *Chairmen*

Panel of Experts

A. A. Wallach, Kaiser Engineers
W. C. Mason, Dorr-Oliver Inc.
C. Lynn Peterson, Peterson Filters and Engineering Co.
W. A. Jordan, General Mills Inc.
R. P. Ehrlich, Rio Tinto Management Services
B. S. Crocker, Kilborn Engineering Ltd.
J. T. Sherman, U. S. Atomic Energy Commission
D. A. Dahlstrom, Eimco Corp.
E. J. Roberts, Dorr-Oliver Inc.
R. R. Porter, Consultant
R. H. Lowe, American Cyanamid Co.
R. S. Olson, Dow Chemical Co.
N. N. Schiff, Vitro Rare Metals Co.
R. J. Woody, National Lead Co. Inc.

Summary papers (5 min each) by each of the following panel members will be presented to initiate open discussion with all attending invited to participate:

Thickening: *E. J. Roberts and R. J. Woody*

Filtering: *W. C. Mason, D. A. Dahlstrom, and C. Lynn Peterson*

Flocculants: *W. A. Jordan, R. H. Lowe, and R. S. Olson*

Fluorspar Mining in Hardin County, Illinois

Total U. S. consumption of all grades of fluorspar in 1956 was about 600,000 tons. About half this supply came from domestic sources. Hardin County production historically accounts for more than 50 pct of the U. S. total.

LARGEST known fluorspar deposits in the world are mined in southern Illinois (Hardin County), and northwestern Kentucky (Crittenden County). Colorado, New Mexico, Montana, and Utah are the principal western sources in the U. S.

Rosiclare Fluorspar District

Hardin County, Illinois

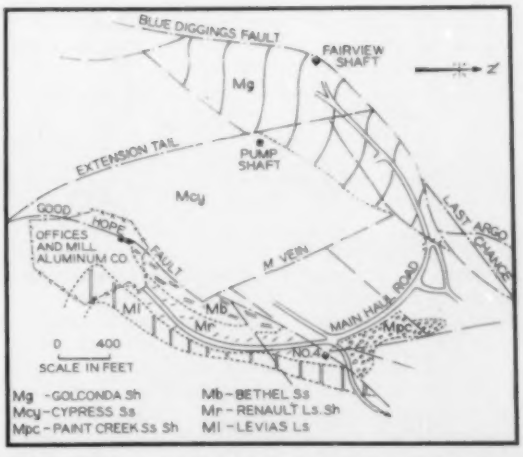
The Rosiclare area is located in the southern part of Hardin County on the Ohio River where the Illinois Central Rd. branch line terminates and provides transportation. Fluorspar has been mined commercially in this area since 1870. Aluminum Co. of America and Rosiclare Lead & Fluorspar Co. are the two major producers in this area. Ozark-Mahoning Co. operates a concentrating plant in Rosiclare but the bulk of its ore is mined near the town of Cave-in-Rock.

Geology: The deposits of the Rosiclare area are predominantly fissure filling type and have been developed in a fault complex which trends northeast-southwest. Displacements on these faults range from almost 0 to 650 ft. Surface formations range from Fredonia lime in the footwall to Tar Springs sandstone in the hanging wall.

This report is based on material used in conjunction with an AIME field trip sponsored by the St. Louis Section in cooperation with the following companies: Aluminum Co. of America, Fluorspar Div.; Ozark-Mahoning Mining Co.; Minerva Oil Co.; and Rosiclare Lead & Fluorspar Mining Co.

Prospecting: Because of the intense structural deformation, the area has been amenable to effective surface geological studies and prospect shafts. Diamond drilling is used for investigations in depth.

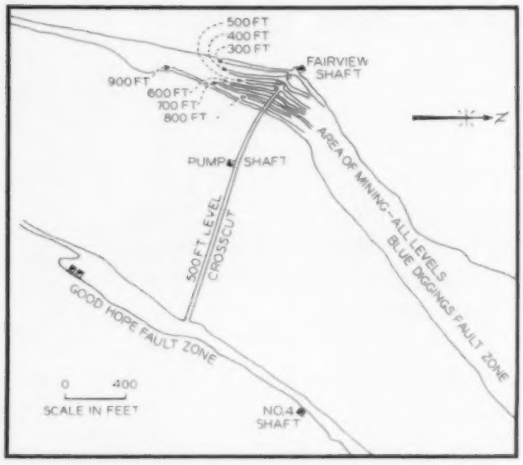
Mining: Access to the Aluminum Co. of America mines is through the Main or Fairview shaft, which is 800 ft deep, with a winze to the 900-ft level. Mining levels are developed at 100-ft intervals. Ore is



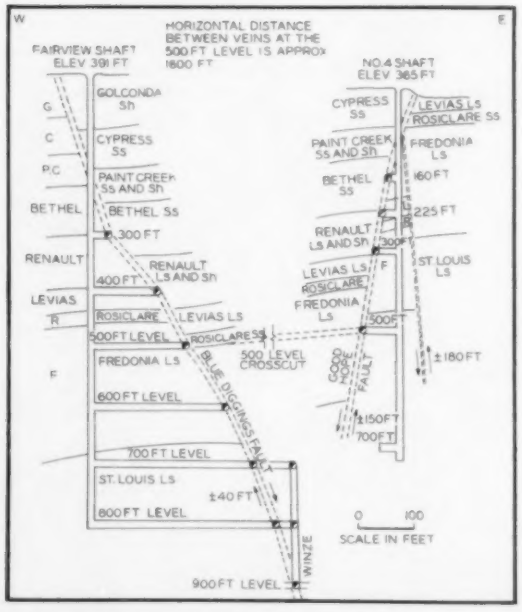
Generalized relationship of major fault outcrops and surface rocks, Rosiclare district.

removed from the veins by a modified shrinkage stoping method where ore and walls stand well. By this method progress is made upward in the vein to form a large storage bin which is kept full until stoping is completed to or near the level immediately above. Access to the top of the stope is through manway raises; access for mining is provided by drawing off some of the broken ore from time to time to form a working space between broken ore and the unbroken ore above.

The material is moved to the shaft by track haulage and is then hoisted by automatic skips to surface storage bins. Trucks transport the ore to the mill stockpile.



Two major fault zones mined by the Aluminum Co. of America at Rosiclare.



Generalized west-east cross section of Fairview and No. 4 shafts, Aluminum Co. of America.

Alcoa Mill: After crushing, separation is accomplished by the heavy-media section of the mill. A ball mill regrinds the enriched ore to a size suitable for flotation feed.

Lead and zinc sulfides are removed and cleaned for shipment. Of the remaining material only the fluorite is recovered and further cleaned until an acid grade concentrate is obtained. This concentrate (over 97½ pct CaF_2 with less than 1 pct silica) is then filtered and dried, finely ground, and stored in bins. It is finally put into covered hopper railroad cars and sent to other Alcoa plants for eventual use in the aluminum reduction process.

Cave-In-Rock Fluorspar District

Hardin County, Illinois

The Cave-in-Rock district is located in the eastern part of Hardin County about 3½ miles northwest of the town of Cave-in-Rock. Mining has so far been confined to an area about 1½ miles wide and about 5 miles long, parallel to the Peters Creek fault. There are two major producers in this district, Minerva Oil Co. and Ozark-Mahoning Co.

Geology: The surface formations in the area range from St. Louis and Fredonia limestones of the Meramec group to Caseyville and Tradewater of the Pennsylvanias. The formations dip to the northeast, parallel with the Peters Creek fault, about 5 ft in 100 ft. The structures in the mineralized area southeast of Peters Creek fault are of small magnitude with displacements ranging from 0 to 20 ft.

Orebodies: The orebodies of the district are flatlying replacement or bedded types. Replacement occurs on three main stratigraphic horizons as follows:

1) Renault lime replaced capping formation Bethel Ss

2) Fredonia lime replaced capping formation Rosiclare Ss

3) Sub-Rosiclare zone capping formation Fredonia Ls

Minerals contained are fluorspar, sphalerite, galena, barite, and minor amounts of pyrite, marcasite, chalcopyrite and witherite. Calcite and quartz are the principal gangue minerals.

These minerals occur in various combinations ranging from sulfide-free fluorspar as in Minerva's Crystal Mine, to the complex fluorspar-zinc-lead ore of the Ozark-Mahoning Co.'s W. L. Davis-Deardorff orebody. Germanium and cadmium are present in the zinc sulfides of certain mines.

Mining: Orebodies are developed either by vertical shafts or, in the case of the shallower mines near outcrops, by truck inclines.

Use of the room and pillar method results in an extraction of 80 to 90 pct. Drilling is done with jumbos and one-man jackleg drills. Loading equipment consists of track mounted loaders, slushers, and various types of diesel-powered loaders. Haulage may be by rail or diesel trucks.

Hoisting is by the Tri-State type of can hoist, caged cars or skip—the trend is toward skip hoisting. Electric power is supplied by REA (Rural Electrification Administration) through a 69,000-v system which crosses the district.

On the surface, contract haulers are employed where necessary. Crude ore or concentrates are moved on state roads. Connections from mines or concentrating plants are over county or private gravel roads.

Milling, Minerva plant No. 1: This all-flotation mill, erected in 1943, treats 275 tpd of complex zinc-fluorspar ore which is hoisted from the adjacent shaft of Mine No. 1.

After primary crushing at the shaft bottom, ore is hoisted to a surge bin over the secondary jaw crusher. Some mine surplus can be withdrawn or added at this point. After screening, third-stage crushing is done by a Pennsylvania impactor. Ball mill feed is reduced to −⅜ in. and grinding is held to approximately 80 pct through 200 mesh. Four ball mills operate on various sizes. All material passes through the zinc flotation circuit. The zinc concentrate contains approximately 1.0 pct cadmium and 0.03 pct germanium and is barge-loaded at Cave-in-Rock for movement to the smelter via the Ohio River.

The fluorspar circuit is fairly complicated and is often altered to suit ore changes and product demands. At different points the following grades of fluorspar concentrate are taken off and stored separately in froth storage tanks, prior to filtration and drying: acid grade, 97 pct; CaF_2 No. 1 ceramic, 95 to 96 pct; glassmaker's special, 92½ to 94 pct; and No. 2 ceramic, 88 to 90 pct. All grades are sold in both bag and bulk form.

MAJOR FLUORSPAR USES

Steel Industry: In gravel or pellet form, fluorspar acts as a flux for steel-making in the basic open hearth furnace.

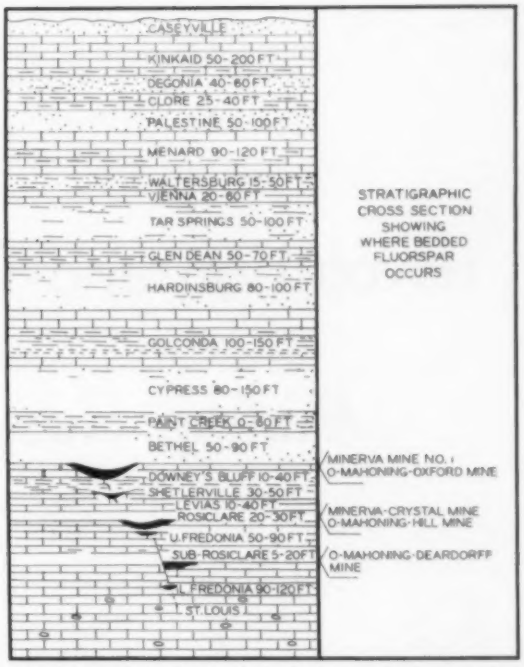
Aluminum Industry: Finely ground fluorspar is the basic compound in the manufacture of synthetic cryolite, a sodium aluminum fluoride. This electrolyte is essential in reducing aluminum from its oxide form.

Ceramic Industry: Fluorspar is used in the manufacture of opalescent, opaque, and colored glasses, porcelain enamels, facings for bricks, and as a bonding agent in emery wheels.

Chemical Industry: Fluorspar yields hydrofluoric acid when reacted on by sulfuric acid. This fuming liquid, in turn, is an important compound in the manufacture of refrigerants, the pressurized gas (Freon) for aerosol containers, and resins for fluoro-plastics. Other expanding uses of the mineral and its derivatives include high octane gasoline production, uranium fluorides for the atomic energy program, and production of high energy fuels.

DOMESTIC CONSUMPTION

	1950	1951	1952	1953	1954	1955
Steel	241	276	273	287	196	242
Aluminum	54	63	70	93	110	112
Ceramics	61	69	69	76	59	65
Chemicals	70	89	108	130	115	131
Total	426	497	520	586	480	550



Formations of the Cave-in-Rock district, Hardin County, Ill.

Minerva maintains a large assay and metallurgical research laboratory and builds much of its own mining equipment.

Crystal Mill, Minerva Oil Co.: This versatile concentrator can produce metallurgical gravel and ceramic and acid grades of fluorspar, and also incorporates a lead and zinc flotation section. The heavy-media section can handle 800 tpd when making gravel spar. Minus ten mesh material goes to the flotation section. A 7-ft heavy-media separator is employed, and is also used as a pre-concentrator on low grade ores. Most of Minerva's acid grade is produced here because ores from the adjacent Crystal, Victory, and Benzon mining operations are free-milling Fredonia limestone replacement.

Ore is brought directly from the mine faces, through sloping diesel truck adits, to the crusher station on the hillside above the mill and the ore passes through three crushing stages before reaching the heavy-media plant.

Milling, Ozark-Mahoning Co.: This plant is located on a spur of the Illinois Central Rd. at Rosiclare, Ill. The ores are delivered to the crushing section by 18-mile truck haul and dumped into one of four receiving hoppers. The mill employs a jaw crusher followed by vibrating screen and Symons cone crusher to reduce the ore to −½ in. Primary grinding is handled by three conventional ball mill-classifier units.

The flotation section consists of three circuits: lead sulfide, zinc sulfide, and fluorspar. Both acid and metallurgical grades of fluorspar are produced. The sulfide concentrates, in the form of filter cake, are loaded into box cars for rail shipment. Concentrates from the fluorspar circuits are sent to the drying section where the acid grade material is filtered, dried in rotary kilns, and elevated into dry storage bins or a railroad car loading hopper. Shipment is in bulk or in paper bags. Metallurgical grade filter cake is pelletized prior to shipment to the steel industry.

Evolution and Organization of a Mining Research Program

by Marling J. Ankeny

MINING research in the U. S. today is indeed complex, whether it involves the Government, a small private concern, or a large one. And it promises to become more so, despite great advances already made in developing equipment and technology.

The U. S. Bureau of Mines is committed to place greater emphasis on mining research as expressed in a recent policy statement to Congress on the "Long Range Minerals Program," by Secretary Fred A. Seaton, quoted above.

While the Long-Range Minerals Program was being formulated, those in the USBM were not treading water but, to put it candidly, they were learning new strokes. They made a frank appraisal of past work at the USBM and of the program now under way. They also looked into the future, guided by the decision that the Bureau would try to serve as many people as possible, avoid duplicating efforts by industry, and likewise avoid becoming consultants to individuals.

In 1956 the U. S. produced about $17 billion in minerals of all classes, including liquid and solid fuels, metals, and nonmetals, valued at mines. The segment of the industry discussed here includes only coal, metals, and nonmetals.

The value of these minerals is estimated at $7.9 billion, distributed as follows: $2.6 billion for coal, $2.0 billion for metals, and $3.3 billion for nonmetallic minerals.

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This article is based on a talk given by the author before a luncheon meeting of the Society of Mining Engineers of AIME at the Southeastern States Mining Conference, October 1957.

The U. S. mines about 525 million tons of coal, 850 million tons of nonmetallics, and 250 million tons of metallic ores annually, or an aggregate of 1.625 billion tons. About 500,000 employes are engaged in extracting these minerals.

It is obvious that before a program can be developed the field must be defined and understood. If mining is to be considered as a composite, it should be possible to recognize where the process begins and where it ends.

In this analysis the USBM has considered that the process begins after the mineral discovery has been made and the geologic setting determined and after there is some degree of certainty that the deposit can be mined economically.

It is considered that the mining process ends with delivery of the raw mineral to a plant for grade improvement. In special cases some preparation—such as crushing, screening, and cleaning—might logically be considered part of the mining process.

The composite mining process can be divided and subdivided in many ways. The main problem here is to divide it in a manner that will be helpful in evolving and organizing an integrated research program. For this purpose, there appear to be four natural divisions of activities—preparatory functions, direct mining functions, supporting mining functions, and comprehensive functions.

In the category of preparatory functions, the mining engineer is interested in collecting the information required to enable him to determine the economic rate of production, design development workings and mining methods, select equipment, and design the mining plant. He needs more exact infor-

A long-range research program must also concern itself with the development of improved mining and processing methods in order that lower-grade reserves may be brought into production. The program within this field will be directed toward the elimination of elaborate and costly supporting structures in mines, toward the development of continuous and automatic methods of extraction in order to achieve greater efficiency, and toward the solution of problems of material handling and transportation in order to lower the cost of moving ore.—*Fred A. Seaton*

mation on the character and setting of the mineral deposit than usually is obtained by prospecting.

Research in this field would be concerned with devising and improving techniques and instruments in order to obtain more accurate engineering data that will enable the engineer to pre-design the mine and plant.

Direct mining functions, comprising the second phase of the mining process, include drilling, fragmentation, loading, transportation, and ground stabilization and control. These are familiar terms, except probably the last. *Ground stabilization* includes any natural or artificial method of support to prevent failure of the rock, and *control* refers to the methods of handling caving or subsiding ground. The research program in this field would parallel these functions and would be concerned with the mechanics of both equipment and rock.

The third major division of the mining process includes all of those special functions required to support the exploitation of a mineral deposit—ventilation and air conditioning, energy distribution and utilization, communications and control systems, water supply and control, and repairs and maintenance of equipment. Problems related to these functions would be the subject of research in this field.

The fourth major division includes the overall aspects of the mining process such as management, general engineering and geology, health and safety, and office and supply services.

A parallel division of the research program, *comprehensive investigations*, is primarily concerned with either broad studies covering the entire mining process or some major part of it. It also includes the major tools available to the research engineer in appraising and evaluating the entire process or some part of it. These comprehensive investigations include health and safety research, mining methods and practices studies, development of mining engineering principles, development and application of industrial engineering and operations research techniques to mining, development and application of statistical methods to mining, and mining engineering economics.

Health and safety research and studies are integral parts of all direct and supporting mining functions where recognized hazards exist that can be reduced or eliminated.

Studies of mining methods and practices were actively pursued by the USBM before World War II. This activity has been resumed during the past two or three years. It comprises the collection of information on practices and performance at operating mines and publication of these data in circulars.

The objective of mining research, particularly experimental research, is to produce data that can be set up in formulas or stated as a hypothesis or rule the practicing mining engineer can use in planning and executing his work—for example, laying out a drilling round, determining a mining level interval, determining the relation between rate of advance and rotation, thrust, torque, and other variables in drilling. This activity has been termed *development of mining engineering principles*.

The terms *industrial engineering, operations research, statistical mathematics,* and *engineering economics* are too well established to require explanation here. Research by the USBM in these fields would be directed toward developing them as tools for the practicing and research engineer to use in appraising technical data and mining operations.

In the process of evolving a mining research program, it soon became apparent that there are a number of functions as important to an integrated mining research organization as an analytical laboratory is to metallurgical research or a machine shop to a mining operation. These have been termed *technical services for mining research organization.* They include physical properties of rock testing, electronic and instrument development, engineering design, and model preparation and testing.

Another look at these outlines of the mining process and the mining research program emphasizes the fact that their technology differs from that of other research fields of the mining industry, such as fuels technology or metallurgy. Basically, the mining processes are concerned with the science of physics and, more specifically, the branch of mechanics in physics, rather than with chemistry.

Who then are these research people who must come forth with equations and theories and recommendations that sometimes appear contrary to age-old practices and customs?

At the outset, their educational backgrounds must be radically different from those engaged in other fields of research in the mineral industries. Our failure as mining engineers to recognize basic differences between research in mining and other fields of the industry may have been a considerable factor in slowing the progress in mining research.

Those who studied mining engineering "X" years ago were told that mining engineering was a combination of most other engineering professions. The mining engineer was supposed to be a jack of all trades—a civil, mechanical, electrical, and hydraulic engineer, among others. He was also to be a chemist, surveyor, draftsman, business administrator—a sort of general practitioner.

Over the years, especially since World War II, mining has become much more competitive and diversified. It is the feeling of many that the day of the *general practitioner* is about finished except in top positions where he can employ specialists to handle specific projects.

So it is with mining engineers devoted to research. They must be willing to specialize and, as in the USBM, to study constantly so they can keep abreast of the latest scientific and engineering developments in the field and in the laboratory.

This need for specialization, brought about by the complexity of mining, affects the pattern for a research organization. It suggests that the organization should comprise groups, each concerned with one or more functions of the research program. The functions for which each group is responsible should be closely related technologically.

Each group should comprise engineering, technical, and scientific skills adequate to cope with all the problems related to the functions for which the group is responsible. The functions of each group should be broad enough to permit employment of full-time specialists. Means should be developed for coordinating the research efforts between the various groups and between the aggregate groups and outside research.

There are many ways of organizing to conduct a completely integrated mining research program. An idealized mining research organization—not necessarily the one it is hoped will be developed in the USBM, but certainly the one to strive for—would be divided into several groups specializing in general engineering, drilling and fragmentation, ground stabilization and control, hydraulics and hydrology, ventilation air conditioning and pneumatics, and mechanics and electricity.

General engineering would include mining engineering and health and safety engineering. These two groups are the only ones that are made up essentially of *general practitioners.* The mining engineering group would be concerned with mining methods and practices studies, engineering evaluation of technological information collected from outside and within the USBM and overall correlation of research developed by the specialized groups.

To perform properly the functions indicated, the mining engineers must be familiar with the engineering tools required in their evaluation work or else employ specialists in industrial engineering, statistical mathematics, cost engineering, engineering economics, and probably others.

Similarly, the health and safety engineering group would be concerned with collecting and disseminating information on health and safety problems aimed at reducing or eliminating hazards and correlating the technological information resulting from health and safety research in the specialized groups.

The skills required in a drilling and fragmentation research group would comprise at least physics (mechanics) and mechanical and chemical engineering.

The ground stabilization and control group could be subdivided into a rock mechanics team, which would be concerned with the mechanics of stable, caving, and subsiding ground, and an artificial support and stabilization team. The skills required in a ground stabilization and control group would include physicists, mining engineers, electronic technicians, an instrument maker, and probably a mathematician and mechanical and civil engineering support.

Mining presents enough problems and potential problems related to hydraulics and hydrology to justify the organization of a specialized laboratory to cope with them. Hydraulic mining and transportation and water control in many mines are some of the problems. Hydraulic engineering, hydrology, physics, and probably mechanical engineering are skills required for this activity.

Ventilation, air conditioning, and pneumatics is a specialized field of engineering closely associated with health problems. The need for specialization on research in this field has long been recognized.

The USBM fully realizes that it has little justification for attempting to develop equipment for industry except in very unusual circumstances. However, the many other problems related to the safety, choice, maintenance, repair, and operation of mechanical and electrical devices justify considering a special group to conduct research in this field. Mechanical and electrical engineering, supported by industrial engineering at least, would be required in this activity.

Use of A-C Power on Conventional Mining Sections

by Chester S. Conrad

SEVERAL years ago Pittsburgh Consolidation Coal Co. intensified efforts to combat the hazard of mine fires. The program consisted of three parts in the order of likely accomplishment:

1) Purchase and installation of newer and more practical fire fighting equipment.

2) Establishment of trained fire fighting teams at every mine plant.

3) A drive to remove the causes of mine fires. Experimentation with alternating current on section equipment is a major development in this part of the program.

Use of alternating current to power mining equipment had been recognized as being most practical from the standpoint of safety. A means to replace the d-c traction motor is all that has delayed complete section mechanization with a-c power.

A shuttle car powered with a constant speed motor was placed in experimental use in 1952 and developed to its present design about a year ago. This shuttle car is the type placed in production with other section components at the Williams mine, Harrison County, W. Va., Nov. 6, 1956.

The *conventional* mining section consists of a cutting machine, loading machine, roof control unit, hydraulic-type car spotter, portable rockduster, and two shuttle cars. All are powered with 440-v squirrel cage motors.

The power distribution system that was adopted features a grounded neutral with current limiting resistors in both high and low voltage circuits. All circuit breakers are equipped with ground trip devices, and in the low voltage circuit ground tripping is selective.

Production experience on the a-c section has been satisfactory. Until very recently the panels mined with this equipment have been driven around numerous gas well blocks and finally into a mined section that had been afire in December 1954. At present the panels are being driven according to standard projections, and it is expected that section performance will improve materially.

Even though initial mining with the a-c equipment followed an off-standard projection, performance data was on par with a d-c equipped section. The a-c equipped section showed the lowest cost per ton when compared with all other sections within the mine, no doubt because maintenance costs were 20 pct of the average for all other sections.

Maintenance costs for the a-c section were, for the most part, for cable repair and replacement. Machine delays were of very significant duration and about 75 pct of the lost time could be charged to cables.

There is one important explanation for this high percentage of machine downtime attributed to cable faults. When the program was set up it was made mandatory that machine operators check the trailing cable-ground wire continuity at least once each shift. Also, maintenance personnel were required to inspect contactor compartments weekly and, as part of this routine, impose an actual ground fault on the machine to test out the ground fault relay at the load center. The high percentage of down time charged to cables is indicative of an enforced test routine. Operating personnel are slowly becoming cable conscious, and this is surely a step in the right direction.

Any test routine that includes the personal element is fallible. Trailing cables and load centers should be designed, therefore, to incorporate a system of continuous ground circuit testing so that a

(Continued on page 75)

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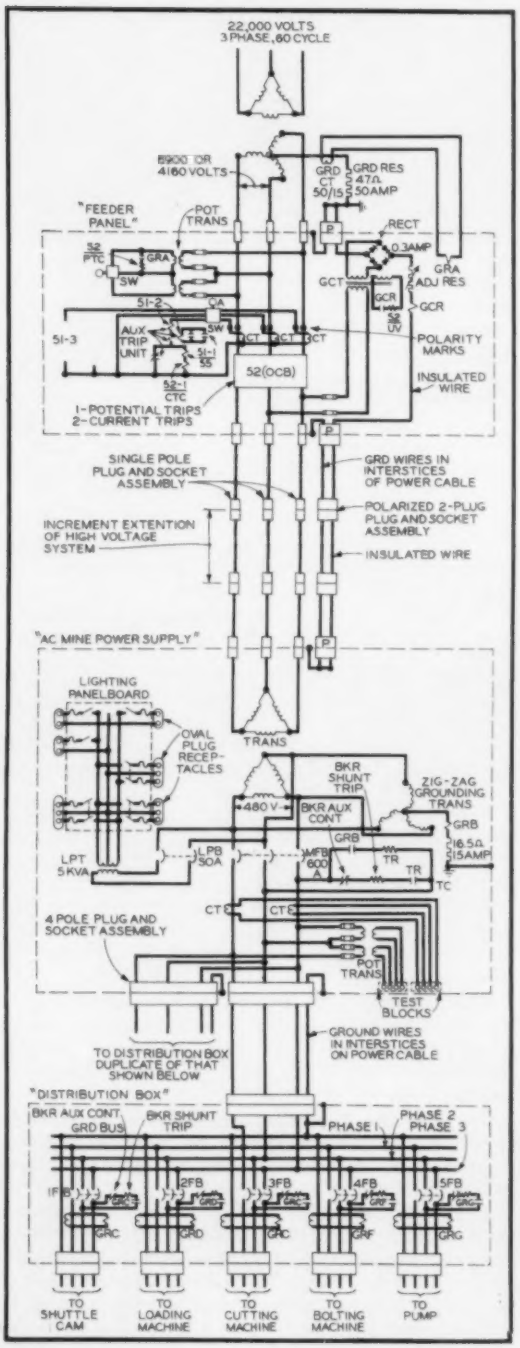
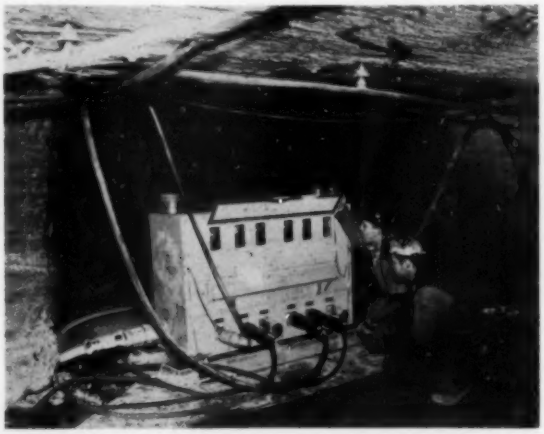
A-C Underground Power Distribution System



Manufacturer's diagram shows surface power transformers, current limiting resistor in neutral of secondary winding, ground current transformer, control transformer, oil circuit breaker with ground relay, overcurrent relays, undervoltage device, and a ground checking device that continuously monitors the ground wires in the high voltage cables to the power center.

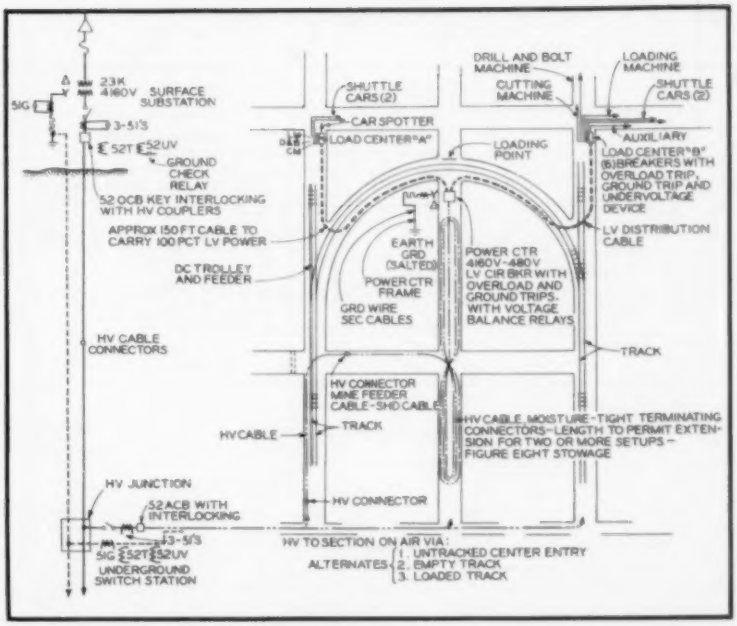
Surface substation.

The power center is a 300-kva unit substation, 4160/7200 v to 480 v, transformer windings connected delta-delta. A ground-current limiting resistor limits ground fault current to 15 amp.

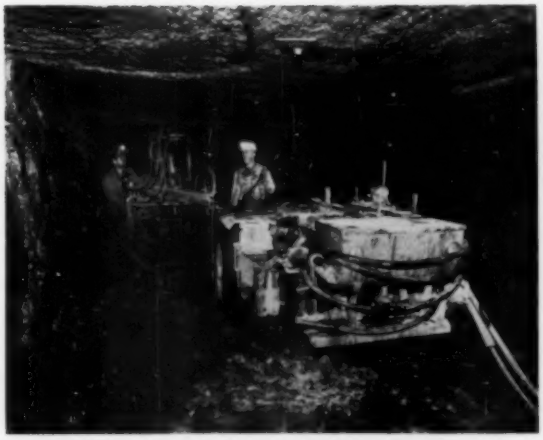


The low voltage load centers on either side of the loading point each provide six circuits having separate breakers with ground trip, overload, and undervoltage protection.

Power System and Mining Plan



Simplified diagram of power system and mining plan. Electrical components include the surface power installation, 23,000 v to 4160 v transformation, power borehole, HV mine feeder cable, HV portable cable, portable power center, LV cables, load centers, etc.



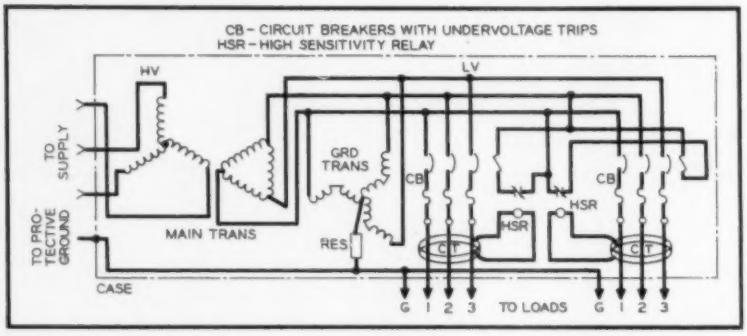
Roof control unit with 20-hp motor.

Cutting machine has 85-hp connected load.

Tor-Kar with 30-hp motor.

Hydraulic pump unit for car spotter, 20-hp.

Safety is primary design consideration



LEFT: Timing relay in power center control permits selective ground tripping. Although circuit breakers in an a-c control can be readily adjusted to assure adequate overload and short circuit protection, it seemed desirable that phase-to-phase faults in trailing cables be eliminated, see below.

Safety Features of Resistance-Grounded Neutral Power System

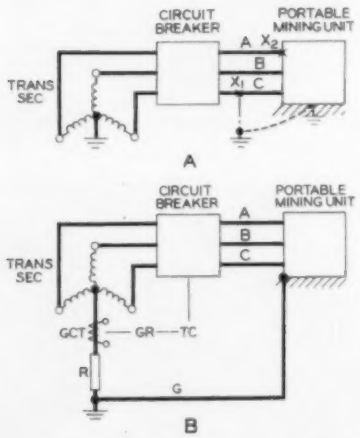


DIAGRAM A: First fault at X_1, phase *C* is at ground potential. Voltage from *A* or *B* phase to ground is full ϕ to ϕ voltage. The unit may continue to operate under this condition.

A second fault at X_2 on the machine frame: Case 1— For a unit with frame resting on pavements the fault path is of relatively low impedance. Fault approaches short circuit value. Case 2—For a unit mounted on rubber tires the fault path has high impedance and the fault current is correspondingly low. However, a man contacting the machine frame constitutes a parallel path to ground and could easily receive a fatal shock.

DIAGRAM B: *R* is a ground current-limiting resistor of 18 ohms. *G* is ground wire in cable; for 20-amp carrying capacity, ohms resistance for 500-ft cable = 1. Resistance ratio is 18:1.

On solid ground (as in case 1 above) maximum voltage drop from machine frame to ground side of resistor is 1/19th the value of line to neutral voltage of transformer secondary. On 480-v equipment, a man would be exposed to 15-v potential when contacting faulted frame.

Trailing cable a-c mining equipment was designed so that cable faults would be ground faults so that arcing currents along the exposed cable between the load center and unit would be limited to 15 amp, and yet not have desired feature complicate repairs to cable. Specifications: 600-v insulation; power conductors, 133 strands; ground conductor, shaped basket-weave copper sleeving, conductor to carry 20 amp, continuous rating; insulation and jacket material to conform with specifications for type G cable.

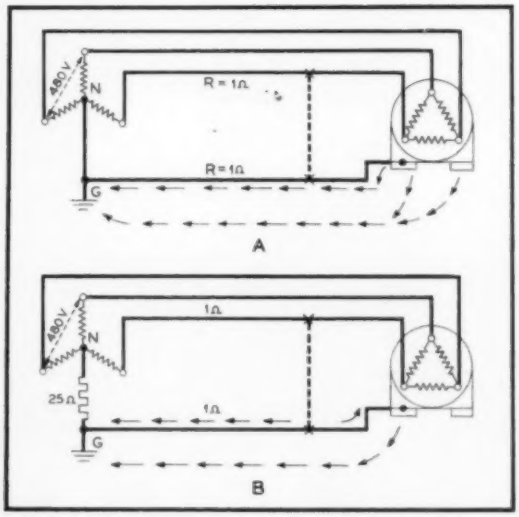
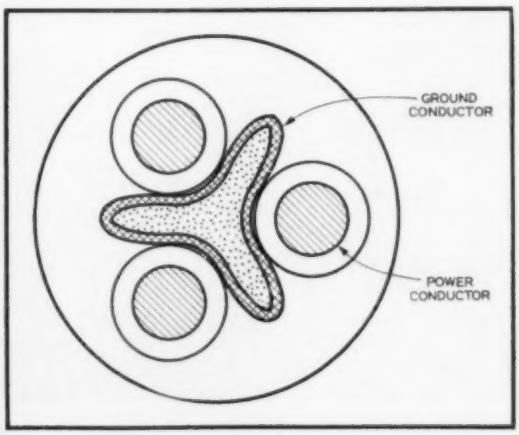
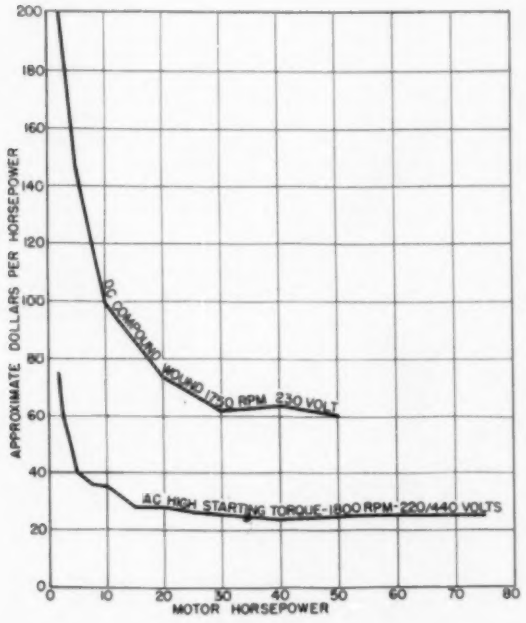
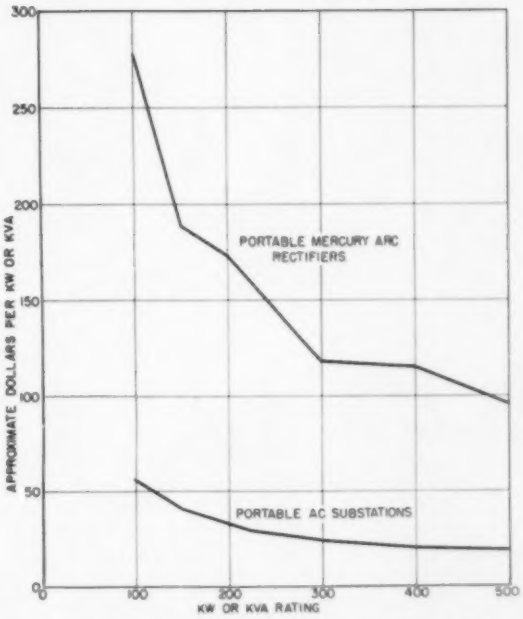


Fig. A—Power system having a wye-connected secondary with the grounding conductor connected directly to the transformer neutral. A phase to ground fault results in high fault current (138 amp) and a correspondingly high voltage drop over the ground wire (138 v). Fig. B—Grounding with wye-connected secondary having a current-limiting resistor in the grounded neutral at the transformer. On a three-phase 440-v secondary connected as shown with a 25-ohm neutral resistor, the current is limited to roughly 10 amp and the voltage drop is 10 v. The value of current is adequate for operation of a circuit breaker trip device and the shock hazard has been practically eliminated.

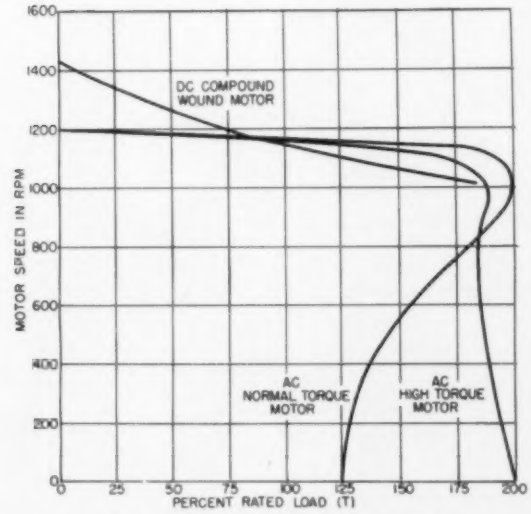



APPROXIMATE DOLLARS PER HORSEPOWER
DC COMPOUND WOUND 1750 RPM 230 VOLT
AC HIGH STARTING TORQUE-1800 RPM-220/440 VOLTS
MOTOR HORSEPOWER

Comparison of motor costs.



Comparison of conversion equipment cost to obtain a-c and d-c utilization voltages.



Typical a-c and d-c motor characteristics.

Effect of Voltage Variation on Full Voltage Motor Characteristics

Characteristic	A-C Induction Motors		D-C Compound Motors	
	110 Pct V	90 Pct V	110 Pct V	90 Pct V
*Starting torque	Increase 21 pct	Decrease 19 pct	—	—
*Breakdown torque	Increase 21 pct	Decrease 19 pct	—	—
Full load speed	Increase 1 pct	Decrease 1.5 pct	Increase 6 pct	Decrease 6 pct
Full load amperes	Decrease 7 pct	Increase 11 pct	Decrease 8.5 pct	Increase 11.5 pct

* Varies as square of applied voltage.

(Continued from page 71)

broken or seriously weakened ground wire will de-energize the circuit breaker to which the cable is connected.

Cable connector key interlocking is also required with the first outby load disconnecting device. It will be necessary to police an installation temporarily to prevent personnel from resorting to short-cut methods, but when they are educated to the seriousness of such practices, there should be no further problem.

As a final word of caution, always strive to insure that the grounding circuit is maintained in first class condition and is continuous to the ground limiting resistor and transformer neutral.

In summary it can be said that the future for application of alternating current to power equipment in underground coal mining holds much promise. Certainly, the limited experience with the system here described does not provide enough data for comparison with d-c systems and equipment in which the experience spreads over several decades. However, a well planned a-c system does provide:

1) Very considerable reduction in fire and *shock* hazards.

2) Correct operating voltage at the equipment.

3) Low voltage lighting on the mobile equipment with the inherent advantage of good lighting and long lamp life.

4) From the power center, a source of a-c voltage suitable for operation of a fluorescent lighting system on the mining section.

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A Comparison of U. S. and European Engineering Schools

by L. J. Parkinson

IN striking contrast to American mining engineering schools, in Europe a new president, known as the *Rektor Magnificus,* is elected each year or alternate year. An exception is Italy, where election is for a period of three years. The Rektor, who is elected by the full professors, must also be a professor and full-time member of the faculty. In most cases there is a Senate, composed of 5 to 14 full professors, some elected and some appointed, which controls the Rektor in policy decisions, but in some institutions there is no such controlling body.

In the same way deans for each faculty or college are selected at the same intervals from among the full professors concerned.

It is difficult for Americans to understand how a large or even a small institution can be governed in this way, how continuity of policy is obtained, and how at times the Senate can avoid selecting a man who may be a great teacher or scientist, but one entirely lacking in administrative talent and experience. The fact remains that it is done and, the writer believes, done well.

Discipline and Control: Under the European system there is no control over attendance at lectures. It is assumed that the students are mature and have developed a sense of responsibility. One professor stated that at his institution attendance at lectures averages 50 pct, and another estimated that for his own lectures the figure is approximately two thirds. An exception to this rule is Italy, where in some courses, at least, attendance is compulsory.

As a general rule no examinations or quizzes are given during the course. Before the beginning of the third year some 14 oral examinations are given, covering the work of the first two years. After the fourth year and after the diploma-thesis has been accepted, final oral examinations are given on the last two years' work. Sweden and Italy are exceptions, giving examinations during the fall following the completion of each academic year. In Italy the school year is not divided into semesters. All courses are laid out for the full academic year and consist of three lectures per week as well as one afternoon of exercises or laboratory work.

Academic Preparation: In most of the countries the author visited, elementary and secondary preparation consists of 13 years of schooling, usually six days per week, rather than the 12 years of five-day weeks offered in the U. S. Studies indicate that the intellectual level of European freshmen corresponds to that of U. S. juniors.

It is here that the greatest difference exists between European and American universities. Their students arrive having a sound preparation in Latin, their own language, and one foreign language. They are well prepared in the world's great literature, in philosophy, history, physics, chemistry, and mathematics. In mathematics they have usually completed analytical geometry, plane and spherical trigonometry, and what is termed college algebra in the U. S. They also have some training in differential calculus and the concept of the infinitesimal.

Since these students have already absorbed a sound knowledge of the humanities and have developed the habit of study, European universities do not have to waste precious time, which averages closer to five than to four years, in teaching what should have been taught in secondary schools.

In Germany the boy who wishes to enter the mining course at a technical university must first spend one year on underground work on practical assignments under the direction of government engineers. The boy is probably 20 years old when he begins his freshman year.

Average Academic Load: In view of the different approach to presentation of courses, it is probably not possible to make a direct comparison with the academic load in American schools, but the average required load in European schools the writer visited is as follows:

School	Lectures Per Week	Exercise or Laboratory Hours Divided by Three	Total Load (Credit Hours)
A	14.9	5.6	20.5
B	17.7	4.2	21.9
C	16.0	3.2	19.2
D	19.9	3.7	23.6
E, F, G	21.0	4.0	25.0
Averages	18.9	4.2	23.0

E, **F**, and **G** are Italian institutions where the course is a common one to all, as it is prescribed by law. On paper the courses at the different schools are exactly the same, but the professors are able to vary the content considerably. It should be mentioned that a few hours of petroleum engineering are included in all the above mining courses.

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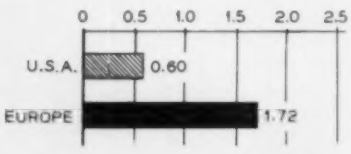
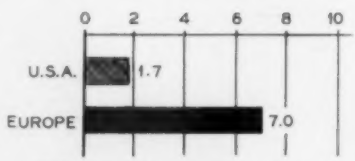
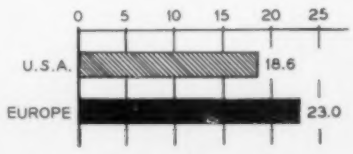


Mining students per 100,000 population (Germany, Italy, Sweden, Austria).



Mining students per million tons of annual ore production.



Average load in semester hours. U. S., 13 schools; Europe, 7 schools.

These notes refer to the training of mining engineers only and not to the general training of engineers for the mineral industries. Petroleum engineers, geologists, and physical metallurgists are specifically excluded.

Included in the comparison are seven European mining schools, two in Germany, three in Italy, and one each in Sweden and Austria.

It is to be noted that the average is considerably higher than the American norm.

Percentage of Applied Courses: There is still no precise definition of what this term means, but it is agreed that an applied course is one in which the so-called *how* is stressed rather than the *why*. However, the writer broached the subject in the same way to each of the professors interviewed and has attempted to reduce their replies to a common base. The figures for percent of applied courses in the curricula are:

School A.

Twenty to twenty-five percent. Corresponds roughly to one year of the four and is about the same as the average American figure.

Schools B, C, and D.

Forty percent. The third and fourth years are almost all applied courses, but as most such courses involve some knowledge of basic sciences and fundamental engineering, the figure has been arbitrarily reduced from 50 to 40 pct.

The time devoted to the principal applied branches is as follows:

Subject	Schools B, C, and D Semester Hours	Pct	An American School (C.S.M.) Semester Hours	Pct
Mining	55	54	29	52
Geology	27	27	18	32
Ore dressing and metallurgy	19	19	9	16
	101	100	56	100

Thus they give relatively less geology than U. S. schools and slightly more of the other two branches.

Schools E, F, and G

Twenty-five percent of a five-year course. The course is really one in geological engineering, since only 4 hr each are devoted to mining and to metallurgy, whereas 24 hr are spent on geology.

To a greater extent than American institutions, schools **B**, **C**, and **D** certainly stress instruction in applied or empirical courses. For example, time spent in erecting and testing boilers and courses in testing of equipment; checking of mining supplies such as steel, cement, and wood; and repair of mining machinery underground are not found in American curricula but are considered by Europeans to be of primary importance.

Possible Changes in Curricula: The full professors interviewed expressed their views as follows:

School A

Perhaps there should be less emphasis on such subjects as mining methods and more on the fundamentals of drilling, including the mechanics of rock breaking.

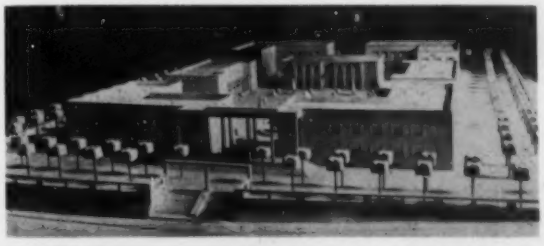
School B

Less work on geology, less on mineralogy, less on ore deposits. More engineering basic sciences—mathematics, mechanics, thermodynamics, and physics. More mine economics.

School C

Less work on geology, mineralogy, ore deposits, and petroleum. Fewer courses in public and civil

TOP: These two buildings constitute the Mining Engineering Quadrangle at the Aachen Technical University, where approximately 500 students are enrolled in the 4½-year mining engineering course. CENTER: Two views of mine ventilation laboratory at Aachen Technical University.



Model of the new group of buildings of the School of Mines at Caglieri, Sardinia. Building is partially completed.

law. More time should be spent on the basic sciences, mechanics, and design and on mining methods.

School D

The professor of mining was absent.

Schools E, F, and G

General agreement that the curriculum common to the three schools requires severe overhauling, as it was fixed by legislation many years ago. Each branch of engineering has so expanded during the past 50 years that the prescribed course of study today is tremendous. Almost no one completes it during the five-year period. Some fields of study should be eliminated and in general there should be more specialization. The three professors are in agreement that the curriculum is too theoretical.

It will be seen, therefore, that educators in Europe are no more unanimous in their views than teachers are in America. There does seem to be general agreement that less geology should be given. This no doubt reflects the mature stage at which the mining industry finds itself in Europe, where there is less exploration left to do than there is in the U. S.

Comparative Number of Mining Students: The four European countries considered here have an estimated total of 1930 mining students and a combined population of 112 million. The average number of such students per 100,000 population is 1.72. In the U. S., with a population of some 167 million, there are aproximately 1000 mining students according to recent data, or 0.60 student per 100,000 population. The European figure on a per capita basis is almost three times that of the U. S. Austria, with a figure of 4.5 students per 100,000, or nearly eight times the U. S. rate, is perhaps overproducing mining engineers. A number of their graduates find work in other European countries.

Perhaps a better index figure is the number of mining students per million tons of ore handled annually. The figures the writer has obtained are from F. Friedensberg's annual mining review and do not include tonnages for sand, gravel, clay, limestone, stone, petroleum, and gas. On this basis the European figure is 7 students and the U. S. figure is 1.7 per million tons, and Europe is producing engineers at about four times the U. S. rate.

The writer can offer no explanation as to why there should be such a great difference in student interest between the two continents, but obviously the opportunities in other lines are better here, or the advantages of being in the mining industry in Europe are relatively greater.

School Contacts with Industry: The writer's strong impression is that relations between European mining schools and their national mining industries are much closer than here. A partial explanation of this may be that there are fewer but larger schools in Europe. In Sweden, for example, there is only one mining school, which graduates all the mining engineers practicing in that country. Naturally, with a loyal body of alumni literally controlling the industry, it is to be expected that the school will enjoy universal *entrée* and support. In Germany, with nearly 1500 mining students, there are but three schools and in Austria only one. Here in the U. S. there are 28 accredited schools, most of them extremely small and hard up for students, and all competing for the attention of the industry.

It also appeared that the mining professors over there carry more weight and have more influence in industry than is the case here. Nearly every one of them with whom the writer came in contact is a director of two or more mining companies and does a good deal of consulting work for industry. One of them is actually the general manager of a group of mines, but is at the school for part of at least three days for lectures. Another maintains a second home in a large nearby mining district and spends his weekends there, where he is a consultant and company director.

The Lesson Learned: Although the differences between European and American educational systems are many, the writer's strong impression is that the fundamental difference is the preparation of students entering the university. If the U. S. is to profit from the European system, the place to begin is the secondary school system. Recently when a group of American engineering educators recommended in a carefully studied report that about 20 pct of the work in U. S. engineering schools be devoted to the humanities, they missed this point, namely, that such subjects should have been covered in the secondary schools.

Instead of reducing the time available for the teaching of engineering, surely we should have the courage to insist that the work designed to give the student a broad background be handled in the secondary schools, as it used to be. Let American parents generally make it plain to the pedagogues that in the U. S. secondary system subjects such as personality development, group adjustment, and basketweaving should have no place—or should at least be limited to students who have no intention of doing work in engineering at the university level.

Adoption of the European system of deciding at the age of 12 or 13 whether the student is to go on to higher educational levels or to be trained in an institution of the *basketweaving* type should be considered. Unfortunately such a procedure today is believed by many to be undemocratic and un-American. Americans should think carefully on this score: the technical schools of American universities should not join in being high-level high schools where students must be taught grammar and spelling, where hardly anyone knows a foreign language well enough to understand and profit by the thoughts expressed in foreign technical literature, and where mathematics is largely forgotten as soon as credit in the course is obtained—although the students expect to become engineers because of the money-making potentialities of the profession.

The second important point to be underlined is that in Europe there is a well defined distinction between the education of a scientist and that of an engineer. The training a scientist receives in America is similar to that given in Europe, almost entirely devoted to the theoretical aspects of the sciences; the differences, as noted above, are in degree of preparation. In Europe the education of an engineer is generally half theoretical and half applied, whereas in America it is about three parts theoretical to one part applied.

Let the U. S. preserve this same distinction between two different educational objectives—the scientific, conducted largely at the graduate level, and the engineering conducted on the undergraduate level. There should be no attempt to develop a hybrid scientist-engineer. Rather, it should be left to nature to provide the occasional genius who meets this description.

(Continued on page 80)

European Mining Scenes and Mining Schools

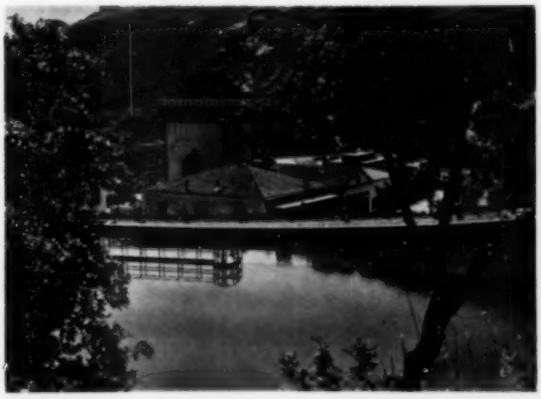
photographs courtesy L. J. Parkinson

SWEDEN:

The administration building of the Royal Institute of Technology, Stockholm, is shown at left. Views center and right are of the buildings and gardens from within the campus.

GERMANY:

Aerial view, left, shows the old Harz Mountain town of Clausthal-Zellerfeld, with the Bergakademie in middle foreground. More than 500 students are enrolled in the mining engineering course at the famous old Bergakademie, whose administration building is shown at right.



ITALY:

"Even around a mine Italians consider the artistic and esthetic side. What American engineer would recognize this (left) as a mine headframe?" Property shown is the Montevecchio lead-silver operation on the island of Sardinia. View at right shows one of the headframes and the treatment plant at Montevecchio.

Organization and Curriculum of One European Mining School

This school is one of four comprising a technical university—schools of general sciences; architecture, construction, and civil engineering; electrical and mechanical engineering; and mining and metallurgy. The school of mining and metallurgy has a mining department, a mine surveying department, and several metallurgy options.

In the mining department there are six full professors, each to some extent autonomous, who report directly to the dean of the school. They are as follows: mining, ore dressing, surveying, geology and paleontology, mineralogy and ore deposits, and machinery.

Of the six professors, details will be given only in regard to the mining professor, who has 11 academic helpers, two secretaries, and a master mechanic. Seven of the academic helpers are part-time men from industry and are rated as assistant and associate professors. Some are paid and others are honorary.

The remaining four academic men would be called *fellows* in the U. S. They are young men having at least a diploma in engineering who are working for their doctorates, or perhaps already have them. They serve as laboratory assistants, go over about 250 theses per academic year, follow all technical literature and articles on behalf of the professor, and are counselors to the students. Note that they are not eligible for promotion in the way that U. S. instructors and assistant and associate professors are. There is only one possibility for promotion in their line and that is for the job of full professor, usually an older man from industry, who is appointed by the government.

The seven associates each lecture from 1 to 4 hr weekly and cover the following subjects:

1) Open pit mining.

2) Ventilation.

3) Explosives and blasting.

4) Wages, piece work systems, support of large underground openings and early detection of underground fires.

5) Examination of mine material for quality control.

6) Mine machinery failure and repair underground.

7) Mining economics.

As an indication of the caliber of man appointed on this basis, the associate in charge of ventilation is the head of ventilation work in the great Ruhr district, involving, on behalf of the Ruhr Chamber of Mines, 155 coal mines with 400,000 workers and an annual production of 140 million short tons of coal. Others are mine managers, mine consultants, and the head of a large machinery manufacturing company.

The other five full professors are also backed up by additional talent along similar lines.

These men come in contact with the students only during the 3rd and 4th years and the 9th semester that follows. During the first *two* years the students' work is given by the faculty of general sciences, much as we here in America do during the first *three* years.

Curriculum — Mining Faculty, School B

Subjects	First Year 1st Semester L*	E*	2nd Semester L	E	Second Year 1st Semester L	E	2nd Semester L	E
Introduction to mining	—	—	—	—	2	—	—	—
Higher mathematice I and II	4	3	4	2	—	—	—	—
Mechanics I and II	3	2	3	2	—	—	—	—
Mechanics III (first semester)	—	—	—	—	3	2	—	—
Physics (experimental) I and II	4	2	4	2	—	—	—	—
Inorganic chemistry for mining students	2	4	—	4	—	—	—	—
Crystallography	—	—	3	2	—	—	—	—
Mineralogy	—	—	—	—	3	2	—	—
Introduction to geology	—	—	3	2	—	—	—	—
Historical geology	—	—	—	—	3	1	—	—
Political economy	—	—	—	—	4	—	4	—
Constitutional and political law, civil code	—	—	—	—	2	—	2	—
DC and AC circuits for miners	—	—	—	—	3	2	1	3
Thermodynamics	—	—	—	—	3	—	—	—
Machine elements (design) I and II	—	—	—	—	2	3	3	3
Technical drawing	—	2	—	2	—	—	—	—
Paleontology	—	—	2	—	—	—	—	—
Totals	13	13	19	16	25	10	10	6

	L*	E*
Theoretical	57½	33
Applied	6	11

Subjects	Third Year L	E	L	E	Fourth Year L	E	L	E
Mining, theory, and practice	6	—	6	—	—	2	—	—
Mining layouts	—	—	—	—	—	—	—	2
Mining seminar	—	—	—	—	—	2	—	2
Open cast mining of lignite	—	—	—	—	2	—	2	—
Economics of mining (cost analysis, etc.)	—	—	—	—	4	—	—	—
Ore and coal dressing, metallics and nonmetallics	3	—	3	3	—	—	—	—
Theory and practice of coking	2	—	2	—	—	—	—	—
Layouts of ore dressing plants (and coal)	—	—	—	—	—	2	—	2
Seminar on ore dressing and coking	—	—	—	—	—	2	—	2
Briquetting of brown coal and anthracite	1	—	1	—	—	—	—	—
Chemical technology with laboratory exercises	—	—	2	—	—	3	—	—
Mining machinery and plant	2	—	6	2	4	2	—	—
Introduction to machine examination	—	3	—	—	—	—	—	—
During vacation, approximately one week in a boiler erection and testing job under government supervisor	—	—	—	6	—	—	—	—
Testing of electric equipment, including M-G sets	—	—	—	—	—	2	—	—
Material testing in mining	—	—	—	—	1	—	1	—
Coal face machinery	—	—	—	—	1	—	1	—
Ventilation	—	—	—	—	2	1	2	1
Surveying I and II	2	—	2	—	—	—	—	—
Surveying instruments	—	—	1	1	—	—	—	—
Drawing of mine plans, including isometrics	—	—	—	2	—	—	—	—
Field and underground survey practice	—	—	—	—	—	4	—	—
Damages caused by subsidence (there is a book on this)	—	—	—	—	1	—	1	—
Practical geophysics	—	—	—	—	2	1	1	1
Ore deposits	—	—	4	1	—	—	—	—
Nonmetallic deposits (including mineralogy)	—	—	—	—	2	—	2	—
General metallurgy (smelting) furnace charges, costs	2	—	—	—	—	—	—	3
Mining law	—	—	—	—	—	—	2	—
Social and labor laws	—	—	—	—	2	—	—	—
Company organizations and calculation of costs, etc.	—	—	—	—	1	1	1	1
Totals	18	3	27	15	22	22	13	14

Of which:

	L*	E*
Theoretical	—	—
Applied	78	56

Total for the four years:

Theoretical	56½ 33
Applied	84 67

A 9th semester is spent on the preparation of a thesis.

* E—Exercise or laboratory.
* L—Lecture.

Trends in Purchasing

The author sees development of a closer working relationship with all phases of enterprise: Management—Engineering—Production—Maintenance. And points up the advantages of this grouping.

by Richard S. Smith

THAT management and purchasing have developed a more closely-knit working relationship is evidenced by the fact that more and more companies are appointing the heads of their purchasing departments to the position of vice president. This is concrete and dramatic indication that management is utilizing the knowledge and experience gained in this department and working with it at the policy-making level.

When the engineering department is at the planning stage of a project, the purchasing department is being asked to sit in on the preliminary discussions . . .today. One result of this cooperation is that drawings and plans will reflect the current situation on material availability and another is that standardization will be incorporated in new construction and equipment.

How many times have there been costly delays on a job that was held up awaiting material merely because the availability of the items had not been checked and verified beforehand? And, how many times has a repair or overhaul job run afoul of a non-standard this, that, or the other part, and required expensive machining or improvization? Such pitfalls as non-standard parts and predictable materials shortages can be circumvented if engineering and purchasing functions can collaborate at the design and planning level.

It was in the production phase of modern industrial operation that purchasing came of age. With the advent of mass production techniques the continuity of the production line and its attendant economies depended largely upon the ability of purchasing departments to set up dependable sources of supply of the correct materials.

Today more than ever production works closely with purchasing to take advantage of all the possible savings available in the new materials and methods constantly being devised. There have been many, many case histories where the purchasing department brought a supplier with a new material or new idea into contact with the right production people to incorporate the change into the end product for substantial savings. By the same token the production department brings problems encountered to the attention of purchasing people.

Relations between purchasing and maintenance departments tell the same story of cooperation. Both being service departments, close liaison and mutual understanding are vital to having the correct material for the job on hand at the right time.

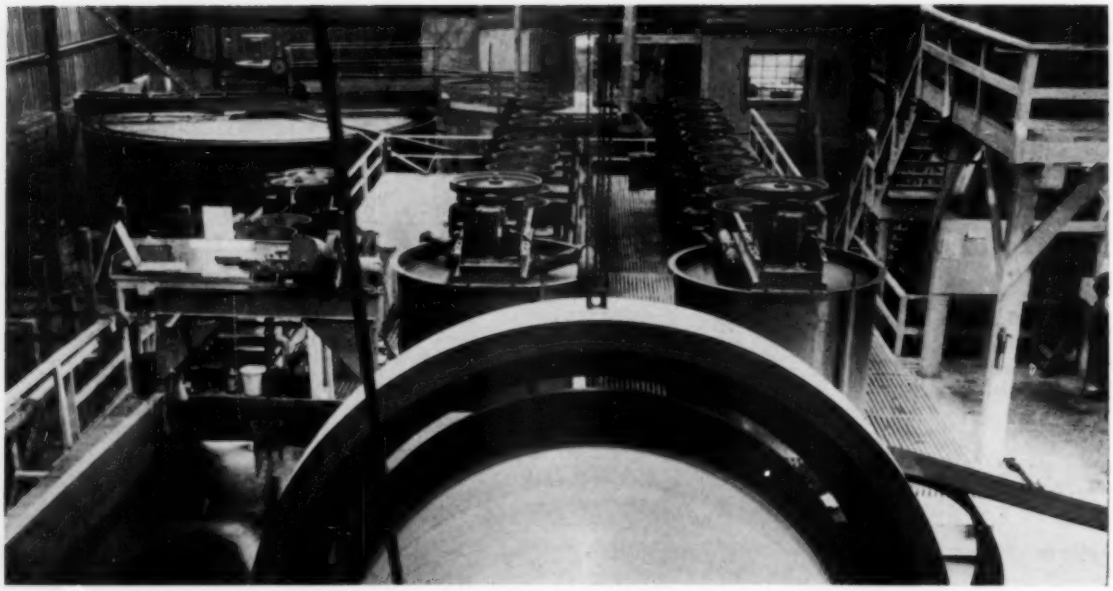
How does purchasing accomplish these functions—how does it become a team member with the other four major operations? At least three of the principal tools at the command of the modern purchasing agent are these: 1) the weekly *Bulletin* of the National Association of Purchasing Agents, 2) the sales representatives of the suppliers, and 3) knowledge of his own company.

The weekly *NAPA Bulletin* presents current market trends for the principal commodities of the world. For the past 20 years the trends outlined in the *NAPA Bulletin* have resulted in the highest average for correct guessing or forecasting of any similar agency in the country. In addition to this, the *Bulletin* provides the purchasing agent with samplings from International Statistical Bureau, United Business Service, Wheatly-Eaton Service, Research Institute Report, McGill Commodity Service, Babson's Business Service, National Industrial Conference Board, Standard & Poor's Corp., Barron's, and others.

Contrary to popular belief, the salesman and the purchasing agent are not natural antagonists—their hackles do not rise when they meet, nor do they glare balefully at one another across a desk. The well-trained, well-versed salesman is one of the best sources for new materials, methods, and ideas today. A mutual trust and respect is the productive climate in which these two work today. (There are exceptions, of course, but they are in a definite minority.)

There may be raised eyebrows when one terms "knowledge of his own company" a tool in the hands of the purchasing agent, but consider for a moment how a man in the purchasing department is going to realize that an offered material, tool, or idea is going to benefit his company unless he can visualize where it might fit in. The more a purchasing agent knows about the functions, the problems, and the possibilities of each aspect of company operations, the better he will be able to function as a purchaser.

The trend in purchasing is toward the development of a creative function—one that is directly related to the special interests of every department. Purchasing can well adopt the philosophy of "divine discontent"—a state of mind that does not permit being satisfied with the way things are being done, that demands a constant search for new materials, new ways, and new ideas.



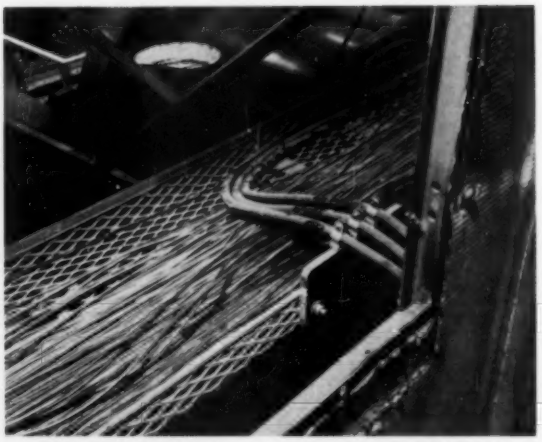
Modern Engineering Turns Abandoned Mine into a Profit

by S. J. Nemeth and N. J. Myers

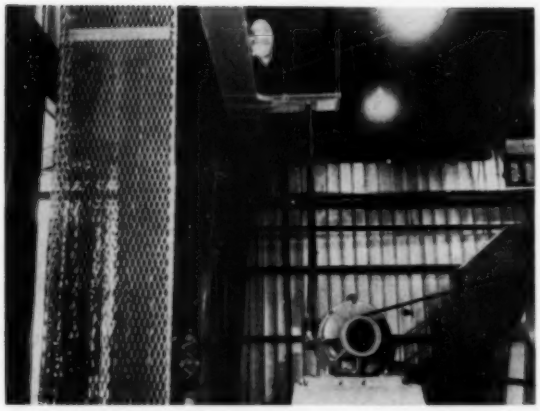
POWER in the mill at Appalachian Sulphides Inc. is provided by 86 electrical motors ranging from 1 to 200 hp and totaling 1200 hp. After a careful study of different types of support for these cables an expanded metal trough was chosen as the most suitable. One hundred and twenty feet of trough were installed in 18-in. width and 150 ft in 6-in. width. This trough carries all the power as well as the control circuits.

Now that the electrical distribution system is complete it is clear that this type of cable supporting system offers many advantages. To handle the same amount of cable in conduit, for example, would have required such a jungle that wiring all the different motors and controls would have been very difficult, even for the original hook-up. In the Appalachian Sulphides operation it has been necessary to make changes from time to time in the wiring of the different motors. These changes are readily made with the present cable supporting system because the

S. J. NEMETH is Mill Superintendent and N. J. MYERS is Chief Electrician, Appalachian Sulphides Inc., Jefferson, N. C.



Cables can readily be laid over the side of cable trough with the aid of special clamps available from T. J. Cope, Div. of Rome Cable Corp. This cable trough system can easily be tied in with an existing conduit system.



Cables pass from two 6-in. troughs below flotation mill to this run 18 in. wide. Trough is covered for further protection of cables.

LEFT: View from control room across mill floor.

Appalachian Sulphides Inc. is reopening a mine that was found in 1856. The original mine was operated for only a decade or so in the boom town of Ore Knob in the Blue Ridge Mountain area of North Carolina. From 1873 to 1883 it was one of the largest producing copper mines in the U. S. The mine was closed down in 1883, and several attempts to reopen it failed. In the early years of World War II a few test borings were made, but these did not indicate that it would be worthwhile to reopen the mine.

Later test borings by Appalachian Sulphides Inc. indicated that a good grade of copper and iron sulfide deposits existed to a depth of 1200 ft or more, with substantial proved reserves. The company decided to go ahead in spite of the high costs involved, not the least of which was the cost of draining the original shaft, which had become completely filled with water.

A new plant was installed, including a modern flotation mill producing copper concentrates. A new shaft was sunk to 1037 ft, and drills have been put into the vein on several levels.

trough leaves the wires accessible for rerouting as needed.

The cable trough not only permits rerouting but also greatly simplifies plant expansion. An expansion program has already begun that will double plant output and there is plenty of room to lay the new cables necessary in the existing trough.

Probably the most important single factor in reducing cable support costs was the reduced installation time. Almost any cable trough system could be installed more quickly than conduit, but the company purchased material from T. J. Cope Div. of Rome Cable Corp., whose system is connected by pins driven through interlocking barrels welded to the ends of each trough section and fitting. These pins are secured in a matter of seconds and the entire system can be installed at a substantial saving in labor cost.

It was interesting to discover that the use of cable trough permitted a substantial saving in copper. Since the air is free to circulate around the cables, the operators take advantage of the higher cable current ratings that are permissible. If cables are enclosed in conduit, more copper is needed to carry a given load. In cable trough the heat is allowed to dissipate more readily and the smaller cables are carried in the same way. It is possible to carry about 20 pct more current than it would be if the cables were completely enclosed.

The flotation process involves the removal of copper sulfide from the iron sulfide and requires additional lime to bring the solution to a pH ranging from 9.6 to 10.2.

Note that cables can be dropped out of control boxes into continuous trough run. The simplicity of such an installation greatly reduces installation costs.

The Humphreys Spiral Concentrator

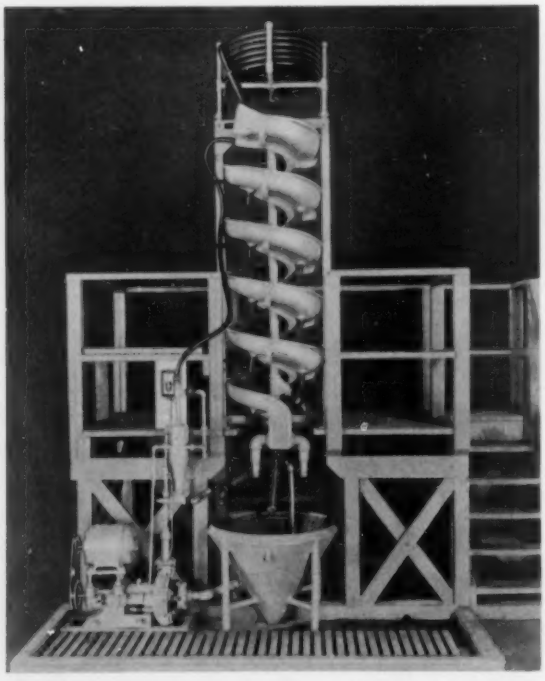
Its Place in Ore Dressing

by James V. Thompson

SINCE it was introduced in 1943 to recover chromite from Oregon beach sands, the Humphreys spiral concentrator has proved successful in several fields of wet mineral beneficiation. By the end of 1957, 9390 Humphreys spirals had been manufactured. Most of these are still in service.

The spiral does not offer a panacea for all mineral dressing problems. Its proper application can best be determined by test work. Spirals present a unique advantage for the metallurgist to make tests in a full-size machine rather than a miniature model, without the risk involved in scaling up results. With only 10 to 40 lb of sample, the operator of a closed circuit test unit employing a full-size Humphreys spiral can conduct preliminary tests with full-scale loadings of 0.5 to 2.5 tph. With larger samples, from 300 to 500 lb, he can run longer multi-stage tests to obtain reliable data for the next step—pilot plant design. The manufacturer of the Humphreys spiral concentrator maintains a fully equipped ore dressing laboratory and by insisting on test work prior to sales has largely prevented misapplication of the spiral.

J. V. THOMPSON, Mining Engineer, Development Dept., Kaiser Engineers Div. of Henry J. Kaiser Co., was formerly a Mining and Metallurgical Engineer, Humphreys Investment Co., Denver.



Advantages of this Humphreys unit include lower costs of installation, operating labor, and maintenance.

Fundamentally the Humphreys spiral concentrator is a wet gravity concentrator, and it operates within these limitations. Its wide acceptance, where it is applicable, is not based entirely on academic metallurgical efficiency. The principal advantages of the spiral are evident in such factors as high capacity per manshift of operating labor, low installation cost, low cost of operating labor, and low maintenance cost due to absence of moving parts. No power is required except for feed delivery, an item common to all concentrating devices.

To realize maximum economy as expressed by these factors, spiral plants are best suited to large tonnage operations. Small installations of one to four spirals seldom demonstrate economies or greater operating advantages than competitive equipment of the same hourly capacity.

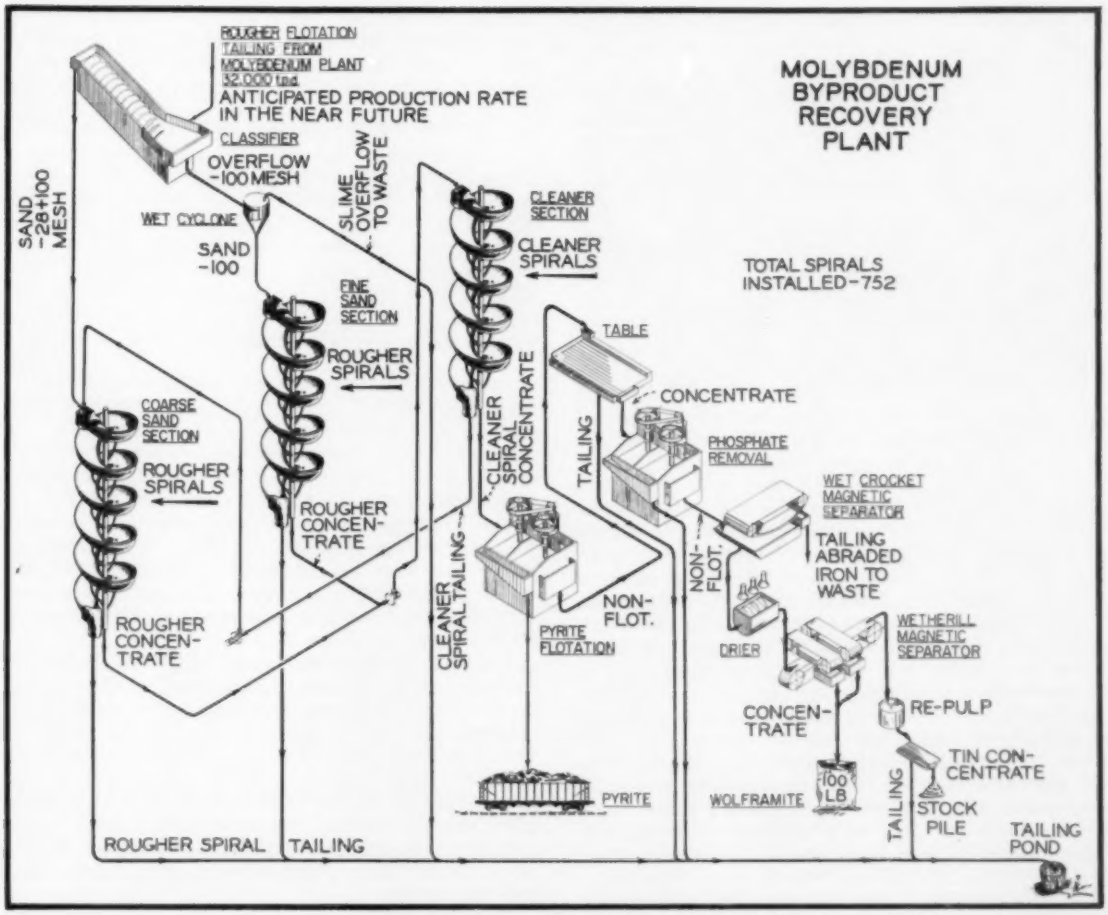
Wear on spiral sections, once a serious problem in a few plants, has been counteracted by the use of castable ferro alloys for some ores and by rubber lining where both erosion and corrosion are problems.

Requirements for Spiral Concentration: Valuable heavy minerals to be recovered must generally be −14 + 200 mesh, but outstanding examples will be discussed later where these size ranges are exceeded in commercial practice at both ends of the size scale.

If maximum recovery and grade of concentrate is to be made within the feed size limitations of the machine, the heavy valuable minerals must be liberated from the lower gravity gangue minerals. This is accomplished by grinding hard rock ores and by natural erosional processes where placer ores are involved.

Heavy valuable minerals to be separated from lighter gangue minerals must have a significantly higher specific gravity. Generally, however, the spiral is limited to separations where the specific gravity differences are those found between quartz, feldspar, and limestones of 2.6 to 2.7 sp gr and those minerals whose specific gravity is 4 and higher. Separations between the common 2.6 to 2.7-sp gr gangue minerals and minerals such as fluorspar and the ferro-magnesian minerals of the 3.2 to 3.5-sp gr range are difficult. Separations in the higher ranges—such as separation of galena from sphalerite and pyrite—are indifferent at best, and generally only a bulk heavy mineral concentrate can be made from ores containing more than one species of heavy mineral.

Several medium size commercial applications have been made for mica, phosphate rock, and coal —special applications that are not limited strictly



Simplified flowsheet, byproduct plant, Climax Molybdenum Co.

by these requirements for spiral concentration. The separation of mica and vermiculite from gangue minerals such as quartz, feldspar, and ferromagnesian minerals is dependent on the flaky shape of the micaceous minerals rather than on a significant difference in specific gravity. Feed preparation of micas is important, and generally open circuit rod mill grinding is employed to delaminate the mica. A blocky *book* of mica reacts no differently in the spiral from a blocky piece of quartz or feldspar. Delaminated mica is swept into the *fast water* in the outer portion of the spiral channel, whereas the blocky and/or angular gangue minerals remain in the inner portion of the channel where the velocity is less. Operation of the spiral on mica is somewhat reversed (as it is on phosphate rock and coal). Valuable mineral is drawn off at what would be, in normal heavy mineral separation, the tailing box, and the gangue mineral reports at the concentrate draw-off ports. Operating on micas the spiral can recover mica minerals as coarse as ¼ in. if delaminated, but rejection of gangue finer than 65 to 100 mesh is difficult. These finer gangue sizes tend to report with the mica product. In commercial operation the mica product can be cleaned by treating in a launder that has a 35 to 65 mesh screen as a false bottom. With this device the flaky mica passes quickly over the screen and the finer gangue passes through the screen.

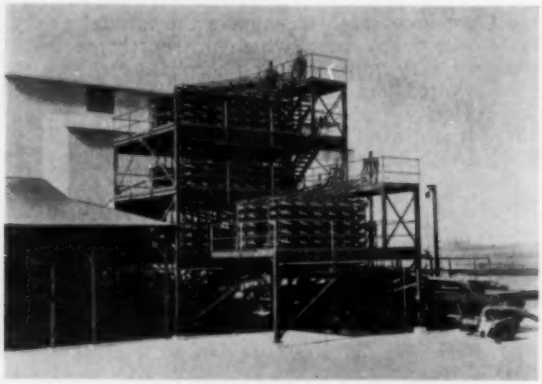
Phosphate rock is another application where specific gravity differences are not involved in spiral separation. The phosphate rock pulp, generally −28 mesh, is reagentized at high pulp density with the usual reagents involved in phosphate rock flotation, such as fuel oil and tall oil. Stated simply, in the reagentized pulp the quartz gangue is wetted by water and the oiled phosphate rock is not. The wetted quartz gangue settles to the inside or lower part of the spiral channel where the velocity is low and is removed as a tailing via the normal heavy mineral draw-off port, which on most other ores delivers heavy mineral. The phosphate rock, which is not wetted and in part *floats*, is swept into the high velocity water of the outer spiral channel, where it is drawn off in what would be, in a heavy mineral separation, the tailing box.

Fine coal below ¼ x 0 can be cleaned with Humphreys spirals. The model 24-C spiral used for coal cleaning has six turns of the helix in the about the same headroom required for five turns in the model 24-A metallurgical spiral. In other words, the pitch is flatter. Only in the Pennsylvania anthracite region are there commercial plants for cleaning fine coal, but numerous pilot plant tests have demonstrated that many bituminous coals respond well to spiral treatment. When coal is being cleaned, there must be liberated particles of coal of relatively low specific gravity (1.5 to 1.7) and liberated particles of

slate or sandstone gangue of 2.5 sp gr or higher. The spiral can recover coal as coarse at ¼ in. but does not efficiently reject waste coarser than 6 mesh. Also, waste finer than 65 to 100 mesh is swept into the fast water with the coal. Generally, dewatering the coal with overflow-type classifiers rejects the fine waste. With some bituminous coals, a middling composed of coarse, high gravity slate and low gravity middling is usually easily separated into clean coal and refuse in a simple elutriation column. For this purpose a single pocket sizer has recently been developed by the spiral manufacturer.

There are outstanding examples of applications where the size range of −20 + 200 mesh has been exceeded. Construction is now under way in western Africa on a large iron ore concentrator employing some 384 Humphreys spiral concentrators. The feed for this plant will be prepared by open circuit rod mill grinding. The top size in the mill discharge is expected to be between 8 and 10 mesh. When heavy minerals between −8 and +20 mesh are present in the feed, it is possible to make a rougher recovery on these coarse sizes by employing a high pulp density that keeps the viscosity of the pulp high enough to prevent the coarse heavy mineral particles from being swept into the fast water, where they would report in the tailings. There are difficulties, however, when such rougher concentrates are sent to a cleaner spiral section. The rougher concentrate fed to the cleaner is essentially slime-free and density and viscosity are lower, so that coarse, heavy minerals remain in the fast water of the cleaner spiral and are swept into the cleaner tailings. Since the cleaner tailing is usually recycled to the rougher feed, there is a build-up of coarse, heavy mineral, with the result that some of this material ultimately is forced into the rougher tailing.

A very simple system has been devised by the Humphreys Investment Co. engineers to avoid such difficulty almost entirely and permit a multi-stage spiral plant to operate on coarse feed. The rougher spiral concentrate is composed of all sizes of heavy minerals present in the feed, but the gangue content is generally finer than 28 mesh. Consequently, treatment of the rougher concentrate in the simple elutriation or single-pocket sizer produces an underflow of very high grade heavy mineral that is finished coarse concentrate. The overflow, stripped of coarse heavy mineral, is ideally suited for the feed to the cleaner spiral section.



Beach sand treatment accounts for about 36 pct of total number of spirals installed. Plant shown is zircon recovery unit of Humphreys Gold Corp. at Starke, Fla.

Distribution of Humphreys Spiral Concentrators As of Dec. 31, 1957

Field of Application	Approximate Total Spirals	Percent of Total
Florida beach sands—ilmanite, rutile, zircon (almost all Humphreys Gold Corp.)	3374	35.9
Northern U. S. iron ore ranges	1712	18.2
Other iron ore, eastern U. S. and foreign	1638	17.5
Tungsten (Climax Molybdenum Co. only)	752	8.0
Phosphate rock (International Minerals & Chemical Co. only)	374	4.0
Chromite (mostly inactive)	255	2.7
Micas, including vermiculite	239	2.5
Lead, zinc, gold, silver roughing (mostly inactive)	107	1.1
Anthracite coal (all Hudson Coal Co.)	108	1.2
All other, including test units in laboratories	831	8.9
Total	9390	100.0

The above figures are compiled from the manufacturer's sales records. There may be some errors due to shut-down of plants unknown to the author.

An outstanding example of a commercial spiral installation recovering mineral finer than 200 mesh is the byproduct plant of the Climax Molybdenum Co. at Climax, Colo. At this plant 752 spirals recover tungsten from the flotation tailings of the molybdenum flotation plant. Most of the tungsten recovered is finer than 200 mesh and much of it finer than 325 mesh.

Field of Application: Processing Florida beach sands for the recovery of ilmenite, rutile, zircon, stauriolite, and monazite is the largest single type of application of Humphreys spiral concentrators. The ore is ideally suited to spiral concentration, since it completely satisfies the requirements for successful spiraling. The size range is substantially 100 pct −35 mesh + 200 mesh, the minerals are completely liberated, and there is significant difference of specific gravity between the gangue and heavy minerals.

Humphreys Gold Corp., mining affiliate of the Humphrey Investment Co., operates three plants in Florida under various contract agreements with E. I. du Pont de Nemours & Co. and the National Lead Co. There are 3374 spirals—35.9 pct of all spirals manufactured up to the end of 1957—employed in the three Florida beach sand plants.

The northern U. S. iron ore ranges account for the second largest group application of Humphreys spiral concentrators. On the iron ore ranges there are 1712 spirals, or 18.2 pct of all spirals manufactured to the end of 1957. For the most part, spirals on the iron ranges treat the −20 mesh portion of the naturally occurring −8 or 10 mesh fines that are the undersize products of washing plants, jig plants, and heavy media plants. The largest single user of spirals on the iron range in multiple plant installation is probably M. A. Hanna Co. and its affiliated companies, with Cleveland-Cliffs Iron Co. running a very close second.

The third largest category comprises the other U. S. and foreign iron ore applications. This group accounts for 1638 spirals, or 17.5 pct of all spirals manufactured to the end of 1957. Three outstanding plants in this group account for most of the spirals. These are Sierra Leon Development Co., Sierra Leon, West Africa; the Liberian Mining Co. Ltd., under construction in Liberia; and Benson Mines Div. of Jones & Laughlin Steel Corp. at Star Lake, N. Y. Also in this group is the recently built spiral plant at Quebec Iron & Titanium Co. for upgrading Allard Lake iron-titanium ores. The greatest future for Humphreys spirals may be in the field of other

domestic and world-wide iron ore beneficiation. In Canada plants employing 3000 spirals have been discussed, and of course such plants would more than triple the capacity of the largest plants now operating.

These three categories account for 71.6 pct of all spiral installations, but other individual plants are noteworthy. Foremost among these is the unique byproducts plant of the Climax Molybdenum Co. Feed to the Climax spirals is in the tailings from molybdenum flotation and contains considerably less than 0.1 of 1 pct tungsten. Spiral plants are employed for the roughing and first cleaner stage of concentration of tungsten, most of which is −200 mesh. This plant has been well described in the literature.

The spiral section of the plant of the Zonolite Co. at Libby, Mont., recovers the −10 mesh vermiculite, using 48 spirals. In the Florida phosphate field, International Minerals & Chemical Co. operates three plants that treat reagentized phosphate rock in spirals—Noralyn with 176 spirals, Peace Valley with 36 spirals, and Achen with 154 spirals.

Other smaller but interesting applications are found in the Appalachian mineral belt, where several small mica plants using 10 to 30 spirals are in operation. Notable among these are Harris Clay Co. of Spruce Pine, N. C., and the Funkhauser Co. of Hartwell, Ga. The American Cyanamid Co. of Piney River, Va., operates about 30 spirals in conjunction with flotation for the recovery of ilmenite. In the Cartersville, Ga., mineral belt Thompson-Weinman Co. and the New Riverside Ocher Co. operate spirals for recovery of barite. There are several small installations for chromite in Turkey and the Philippines. Several larger operations for chromite from placer deposits have been operated in the past, but all but one are now shut down.

It would be worthwhile to discuss in detail some areas where the Humphreys spirals are definitely not suitable. With one exception, spirals have no application in recovery of sulfide minerals, where flotation has been shown to do a satisfactory and superior job. Spirals cannot make a selective separation of lead from zinc sulfide, nor can they reject pyrite from copper and zinc sulfide ore. Most lead, zinc, and copper sulfide ores require grinding that reduces the bulk of the ore to a size too fine for gravity and consequently too fine for spiral concentration.

The exception is that spirals might be superior to flotation where it is desired to recover pyrite from tailings containing no other heavy mineral: if the pyrite to be recovered from flotation tailings is to be used for iron smelter flux or acid manufacture, the extremely fine sizes contained in the feed material may not be wanted and consequently their recovery may be of little importance. Such pyrite can be recovered without reagents with spirals. Often the use of flotation involves a difficult reactivation problem where the pyrite has been depressed in zinc and copper circuits. Coal fines as a source of pyrite are also a promising application if a market for this pyrite should develop.

There have been many attempts to recover values with spirals from tailings ponds. If the original mill that produced the tailings pond was a jig and table plant, it is seldom that anything remains in the tails that can be economically recovered by spirals. The assay values reporting in such tailings are the result of extreme fines that do not respond to gravity concentration or of locked middlings

Rougher spiral barge, Trail Ridge plant of E. I. du Pont de Nemours & Co. Inc. at Starke, Fla., operated by Humphreys Gold Corp.

which, when reground, may produce more fines that cannot be recovered. Needless to say, little can be recovered in the way of gold values from cyanide tailings or from lead, zinc, and copper flotation tailings, except such byproducts as tungsten, tin, or monazite, which were not the primary target of the flotation or hydrometallurgical effort.

Of the phosphate rocks only Florida ores responded to spiral concentration. Tennessee and western phosphate rocks tested to date do not respond to spiral treatment and were also difficult to concentrate by flotation. A beach placer in Baja California containing free phosphate oolites has been treated with some success in the laboratory after proper reagentizing in Humphreys spirals.

A summary of Humphreys spiral concentrator applications indicates that about three-fourths of all spirals are used for two major applications. The placer beach sands operation of Humphreys Gold Corp. account for 35.9 pct and all domestic and foreign iron ore application accounts for 35.7 pct. Future applications would appear to be in the fine iron ore as lower grade iron ores come into production. The application of spirals to cleaning of fine coal should be re-examined, particularly when large spoil piles exist that could be reworked for fine coal.

Acknowledgment

The author, for several years a metallurgical engineer on the staff of The Humphreys Investment Co., acknowledges his indebtedness to that company for supplying data for this article. On Oct. 31, 1957, Humphreys Engineering Co. was formed by The Humphreys Investment Co. to take over the property and business of the engineering division of the parent company.

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Tracy Mine of Jones & Laughlin Steel Corp.

A report of successful and effective layout despite fact that site preparation and mine plant design were complicated by surface encumbrances and subsidence limits.

by R. W. Braund

THE Tracy mine is within the corporate limits of Negaunee, Mich. The tract of land comprising the Tracy group lies on the east end of the Marquette Iron Range between adjoining mined-out properties on the north and south.

Since acquiring the Tracy lands in 1921, Jones & Laughlin Steel Corp. has completed about 115,000 ft of surface diamond drilling, partially outlining five orebodies. Now that mining has started, one or more underground drills are in constant operation to obtain information that will aid mine development planning. Some 20,000 ft of underground drilling have been completed to date.

Tracy mine orebodies show the common characteristics of ore deposition on this part of the Marquette Range. Basic controls consist of east-west trending troughs, faults, and dikes. Localized controls are subordinate faults and dikes trending in a northwesterly or northeasterly direction. Sills and interbedded slaty bands are occasionally important.

By the fall of 1946 it was believed that enough ore had been proven to warrant development. Engineering studies were undertaken between 1946 and 1950 to determine the economics of a Tracy operation and to evaluate the several possible plant sites. The operation was to be planned for annual production of 1 million gross tons.

Initial activity was confined to clearing the surface of encumbrances. The land comprising the Tracy group straddles a stream valley that had become the site of dwellings, roads, a city garbage dump, utility lines, a trunk sewer line, city water lines, and the tracks of three railroads. Removing and relocating these encumbrances was a difficult and expensive undertaking.

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Engineering studies in the meanwhile indicated that a central shaft and a single plant could be utilized to mine all the ore then known on the Tracy group. Estimated subsidence limits dictated that the plant site must be long and narrow. Fortunately the shaft could be located within 200 ft of the horizontal center of mass of the known ore. It was also fortunate that the elevations of railroad lines east and west of the plant tied in perfectly with the necessary slope and elevation of the stockpile grounds.

Engine House and Hoist House: The engine house is 51 ft wide x 202 ft long, with 35 ft 8 in. clear height inside. Two hoists, four air compressors, and some of the electrical control panels are on the first floor; the control panels occupy a small annex on the west side of the main building. A 32-ton crane serving the main floor also serves the full basement through floor hatches. In the basement are the MG sets for running the hoists, rotary control units, after coolers, and mine electrical control panels. A Trane cooler using antifreeze in closed circuit is used for compressor and bearing cooling.

Major equipment in the hoist house consists of:

One skip hoist, semi-automatic, double drum cylindrical, each 12 ft diam x 6 ft 4 in. long, using 15-ton bottom dump skips.

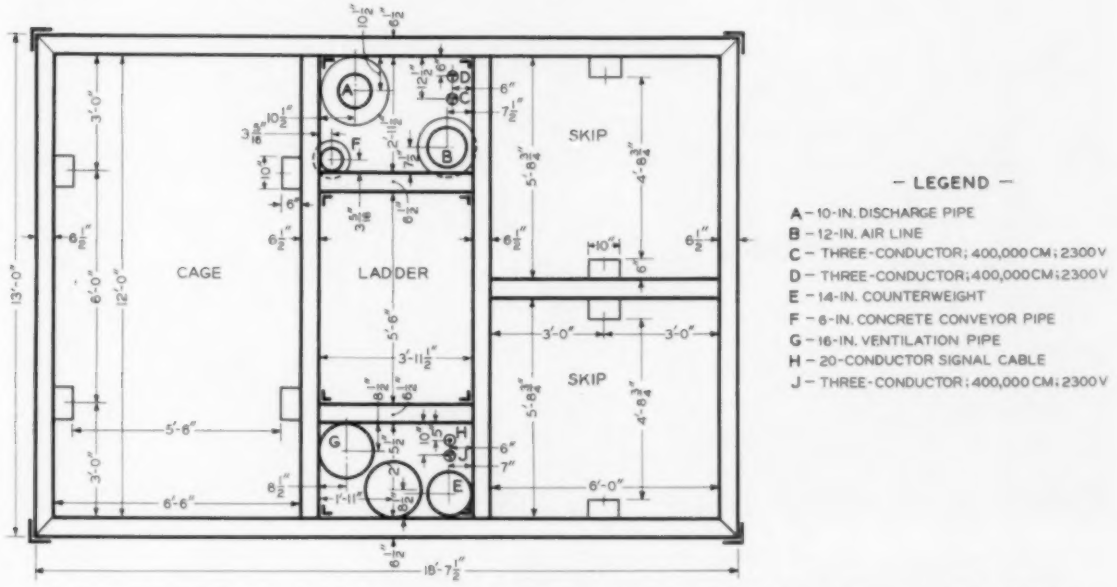
One man-material hoist, double drum cylindrical, each 12 ft diam x 6 ft 4 in. long.

Three 5-step air compressors, 2600 cfm (space for three, two installed).

One 5-step compressor, 1200 cfm.

Headframe and Crusher House: The steel headframe is 160 ft high. Bottom-dump skips of 250-cu ft capacity discharge into a rock bin or by flop-gate onto a pan feeder-screen-crusher-pan feeder to belt combination. A panel-heated slab under the

Steel sets for Tracy shaft of Jones & Laughlin Ore Co.



Steel sets plus reinforced concrete lath, tied into wall rock with umbrella rings, feature shaft design which duplicates other Marquette Range installations to permit interchange of equipment and materials. The 1566-ft shaft provides for a double-deck cage and two 250-cu ft bottom-dump skips.

rock chutes prevents frozen build-ups in winter. At first the discharge impact from extremely wet or very sticky ore caused difficulty in the ore circuit. This was eliminated by placing retarder angles in the skip box and by placing *finger beams* slightly below the point of skip discharge.

Crusher house equipment includes a pan feeder, 6 ft x 16 ft 3 in.; a 5x12-ft vibrating screen; another pan feeder 4 ft 8 in. x 16 ft 9 in.; and a 24x36-in. jaw crusher.

From galleries 64 ft high, 36-in. belt conveyors discharge to the stockpile area. No. 1 conveyor at 14° moves the material to the top of twin-pocket loading bins. At this point the material discharges onto a reversible movable intermediate 48-in. shuttle conveyor, which feeds into either of the pocket bins or onto the No. 2 belt. The No. 2 belt, also at 14°, takes the ore to the top of the stockpile galleries and discharges onto the stockpile gallery shuttles. These are 36-in. reversible conveyors that permit discharging through floor hatches onto the stockpile.

Statistical Data on Conveyors

	Width	Incline	Length	Drive, Hp
Belt No. 1	36 in.	+14°	171 ft	40
Intermediate shuttle	48 in.	+14°	15 ft	15 (reversing)
Belt No. 2	36 in.	+14°	123 ft	30
Shuttle No. 3	36 in.	+1½°	349 ft 6 in.	20 (reversing)
Shuttle No. 4	36 in.	+1½°	615 ft 6 in.	30 (reversing)

The galleries themselves are all welded construction with sandwich side insulation between corrugated sheets. The floor is ¼-in. plate covered with a lightweight-aggregate concrete. The roof is flat, of ¼-in. plate, with insulation on the underside, the upper side being a walkway with side railings. Outlets for electric shovel operation are located on the gallery roof; the shovel is served by drop cable. Estimated capacity of the stockpile ground is 583,000 gross tons over a length of 1311 ft.

Tracy Shaft: The Tracy shaft lies midway between the main group of buildings and the engine house. A double tunnel, over and under, connects the shaft to the buildings on the east; the upper tunnel continues west to the engine house. About 25 ft below the upper man tunnel is the timber tunnel, through which a double track leads to the timber yard. Adjoining the shaft between the engine house tunnel and timber tunnel is a concrete mixing room, gravity-fed from ground level aggregate bins. The concrete is blown underground by pneumatic placer.

The shaft itself is a direct copy of others on the Marquette Range to permit interchanging equipment and materials. The shaft was sunk 1566 ft, four station cut-outs at 200-ft interval were completed, and all shaft cleaning spillage facilities were installed in a little less than 12 operating months on a three shifts per day, six days per week basis. Material penetrated was iron formation passing into footwall quartzites and slaty greywackes. Steel sets combined with reinforced concrete lath, tied into the wall rock with concrete umbrella rings, make a particularly firm and fireproof installation. Two 250-cu ft bottom-dump skips and one double-deck cage serve the shaft.

At least two more levels are contemplated. The levels will serve orebodies on the north, west, and south as indicated below:

Level	Number of Orebodies
500	3
100	3
300	3
100	3
(-300 ft) future	3
(-500 ft) future	3

All surface facilities are connected by galleries or tunnels. This has proved most helpful during Michigan's severe winters. Items of interest within the buildings are radiant heating floor panels in the east end of the shop where vehicle repair is carried on, a 10-ton overhead crane that serves general shop and welding room, a warehouse on ground floor plus a much larger mezzanine, various change rooms, and gravity-flow coal bins with bin-stoker feed to boilers. A full basement under the main change rooms has been invaluable for storage. Division and mine office personnel are housed in the connected office building. All employes use an entrance adjacent to the office; a main corridor leads to the several change rooms. The pay window faces onto this main corridor. An employment and personnel office is just a step off the corridor.

Underground Facilities: Ore is trammed by conventional 30-in. gage mine cars for discharge into trench and thence by scraper and measuring pocket into the skip. Fixed blowpipes using air and/or water are installed in the lower portion of the measuring pockets to assist movement of ore from pocket to skip when necessary.

The present main pumping station is on the 300 level. Three 1500-gpm fully automatic centrifugal pumps discharge directly to surface through a 10-in. line. Installed by mine personnel, air domes to scavenge air on the discharge side of each pump have been completely successful in eliminating an initial severe water hammer problem.

Water from the 100 level is boosted to the 300 level by three 500-gpm pumps. All sumps were designed to permit cleaning by scraping directly into the adjacent pocket trench.

All underground electric current is taken down at 2300 v by armored cable. The 2300-v a-c current is stepped down to 220 v by transformer stations located inside on the levels near the orebodies. Direct current is provided by a rectifier.

A second exit and air intake is provided by an old shaft, called *Tracy B*, 2000 ft westerly of the main, or *A* shaft. Oil-fired boilers warm the intake air. A 5-ft ventilation fan, now delivering about 75,000 cfm at 3½-in. water gage, is located on the 300 level in the drift leading to *B* shaft.

Mining Methods: Three stoping methods are used to mine the ore: block caving accounts for 33 pct of current production; sublevel caving, 50 pct; and sublevel stoping, 17 pct.

The size, shape, and location of the orebody, together with any contained intrusives, dictate the method to be used. Block caving is employed on large blocks of clean ore that has a reasonable height. Sublevel caving is used where the ore is contaminated by dikes or is too thin or small to be mined by block caving. A 25-ft interval is generally employed in sublevel caving, although 40-ft and even 50-ft intervals have been caved using extension rods or auger steel. In narrower vertical lenses of ore and near the tops of some ore blocks sublevel stoping is used until contamination dilutes the grade of ore; when this occurs the rest of the ore is generally extracted by sublevel caving methods.

General Problems: Initially water was a serious problem in the orebody lying south of the plant. The first heading that cut through the ore encountered a 1500-gpm inflow on a dike-fault footwall contact. This inflow, in the drift breast, was eliminated by driving an intercepting drift farther to the east and south where contact was made with a water course feeding the initial inflow.

Three interconnected and flooded mines lying on the north property line were unwatered by a sequence of surface pumps, an air lift, and finally by underground drillholes that bled off the remaining water into the permanent underground pumping station. Another group of flooded mines lying south of the Tracy may eventually be unwatered the same way.

The major problem at the mine has been learning how to handle the ore in its various degrees of moisture content. The ore is earth and tends to arch over grizzlies and hang up in chutes and car bottoms. With increased moisture content, combined with a naturally high specific gravity, the ore has damaging impact if dropped from any height.

The Tracy mine is keeping abreast of the original planned production schedule. Now that starting up problems have been solved, the operation is rapidly shaking down into a satisfactory routine.

Income Tax Treatment of Development and Exploration

- Meaning of "Development"
- Meaning of "Exploration"
- Statutory Limitations on Scope of Provisions
- Disclosure of Ores or Minerals in Commercially Marketable Quantities
- Deductions for Development Expenditures
- Deductions for Exploration Expenditures
- Effect on Basis for Property
- Effect on Percentage Depletion Computations
- Deduction for Losses
- Expenditures Made by Taxpayer
- Pre-1951 Expenditures Later Deductible
- Further Considerations

by Henry B. Fernald

THE Federal income tax treatment of expenditures for exploration and development for mines and other natural deposits (other than oil and gas) was materially changed by special provisions of the 1951 Act that are continued in the present 1954 Code.* These present provisions for mines in the 1954 Code, Secs. 616 as to development and 615 as to exploration, will be considered here.* In substance they are the same as the 1951 amendments to the 1939 Code, Secs. 23 (cc) and (ff), respectively, except that for exploration the allowable annual deduction is increased to $100,000 (from $75,000) and minor changes in case of property transfers are made with respect to the four-year limitation.

Before 1951 the statutes made no specific provisions regarding development and exploration for mines, but the rules were prescribed by Treasury regulations: 1) Before the mine entered the production stage, all development and exploration expenditures for mines, less net receipts, were to be capitalized recoverable through depletion or written off as losses when determined worthless. 2) After a mine entered the production stage, development expenditures were deductible as expenses—currently if ordinary expenses, but on a deferred basis if extraordinary in scope. This recognized the two separate periods, one before and the other after beginning of the production stage. There was no distinction between an exploration and a development period, but exploration was included as part of development.

The present general plan is materially different:

1) During the *exploration* stage (before the development stage begins), expenditures are, as formerly, to be capitalized recoverable through depletion (or deducted as losses when worthless) except that a taxpayer may deduct currently, or treat as deferred expenses, not more than $100,000 of such expenditures of any year, in not more than four years.

2) During the *development* stage (after disclosure of minerals in commercially marketable quantities and before the production stage begins), expenditures for development are to be deductible currently or treated as deferred expenses.

* Provisions for oil and gas and their allowances for "intangible drilling and development costs" continue, as they have for a long time, to be materially different from the provisions with regard to exploration and development for mines.

* See page 95 for copy of Sections 615 and 616 of the Internal Revenue Code of 1954.

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3) During the *production* stage (beginning when major production is from workings other than for development or the principal activity becomes production of developed ore), ordinary development expenditures are currently deductible as formerly and extraordinary development expenditures may either be deducted currently or treated as deferred expenses.

As written into the statute, this general plan, thus briefly summarized, is subject to many technical specifications, qualifications and limitations. However, the brief summary serves to note certain basic differences between the present and the pre-1951 provisions. It is also helpful for consideration of the practical problems that will be referred to in this discussion, but always with the understanding that it will be the proper legal interpretations of the statutory provisions and their application which will control.*

* In consideration of these statutory provisions, the pertinent Congressional Committee Reports seem of great importance in clarifying the meaning and intent of the law. Particular reference may be made to the report of the Senate Committee on Finance with respect to the 1951 Act (Senate Report No. 781, 82d Cong., 1st Sess., pp. 43-45, 63, and Part 2, 21-23, 63-65). See also a Summary of the Provisions of the Revenue Act of 1951 (H.R. 4473) as agreed to by the Conferees, prepared by the Staff of the Joint Committee on Internal Revenue Taxation, October 1951.

Further specifications in Treasury Regulations are also to be considered. Treasury Regulations 118 were issued under the 1939 Code (as amended by the 1951 Act). Proposed regulations (published in the Federal Register of Nov. 3, 1956) under the 1954 Code were subject to some serious protests and had not yet been issued when this article was written. Thus, Reg. 118 are presumably still in effect, but it cannot be known to what extent they may be superseded or modified when new regulations are issued for years subject to the 1954 Code.

The development provisions in particular will be considered here. They make the greater changes and they furnish the background for the special provisions regarding exploration that were drafted later. When the 1951 Act was framed the provisions regarding development were drafted first and included as Sec. 23 (cc). The further provisions regarding exploration were added as Sec. 23 (ff)—although in the 1954 Code, the exploration provisions are stated first in Sec. 615, followed by the development provisions in Sec. 616. The matter of current deductions will be given primary consideration, with only subordinate mention of the permitted elections for deferment.

The following are among the special problems to be considered:

Meaning of "Development"

Neither the laws nor regulations have clearly defined *development* for mines. The extended specifications regarding "intangible drilling and development" for oil and gas are wholly inapplicable to mines.

The Committee Report refers[1] to costs of shafts, tunnels, galleries, etc., necessary to make the mineral accessible as being *included* in development expenditures, but this manifestly does not bar inclusion of other expenditures. The Report further states: "During the development stage, this new subsection is applicable to all expenditures of the taxpayer, unless otherwise excluded herein."[1] The specific exclusions will be referred to later, but this still leaves the question of what *development* may include.

The term *development* is used in various ways by mining men. The cost of development of a new mine may be taken to include all costs of plant and equipment, underground and surface work, facilities and every other expenditure to bring the mine into satisfactory production. However, *development* is unquestionably used by mining men with more limited meaning, often varying from mine to mine.

Perhaps the best definition that is consistent with the statutory use of the term is that given by Hoover: "*Development* is conducted for two purposes: first, to search for ore; and second, to open avenues for its extraction. Although both objects are always more or less in view, the first predominates in the early life of mines, the prospecting stage, and the second in its later life, the producing stage."[2]

As thus defined, *development* would include expenditures for prospecting and exploration. This appears to be the intent of the statute, and its specific exclusions seem to support this thought.

The exploration provisions refer to expenditures for "ascertaining the existence, location, extent, or quality of any deposit," but are limited to such expenditures before the beginning of the development stage, which starts when there is the required disclosure of minerals "in commercially marketable quantities."* Rarely, if ever, is the full extent of commercially marketable ore completely known until the orebody is mined out. After the required initial disclosure that minerals exist in commercially marketable quantities, there is the continuing need, in the development stage and also in the production stage, to obtain further and more detailed information as to the character and size of the orebody and its commercially marketable ore. Certainly such continuing expenditures after the required initial disclosure would not fall within the scope of the exploration provisions but would naturally fall within the scope of development or of production expenses, depending on whether they fell within the development or the production period.

* The House Committee's Report (H. Rep. No. 586, 82d Cong., 1st Sess., p. 107) refers to development expenditures during the development stage "after completion of the initial exploratory work."

The pre-1951 regulations made no distinction between an exploration and a development stage. No beginning to the development stage was specified, but a single rule required capitalizing all expenditures, before the mine entered the production stage, regardless of whether they were for exploration and prospecting or were to provide for extraction of the ore. The present statute, in allowing deduction of development expenditures, makes its special test for the beginning of the development period so that such provisions would not apply to expenditures before such required initial disclosure, as they might otherwise have applied.

During the production stage, the usual continuing exploratory expenditures have long been included in the development expenditures deductible currently or on a deferred basis.

It would accordingly seem that *development*, whether during the development or the production stage, would include the continuing exploratory expenditures after the required initial disclosure.

Meaning of "Exploration"

The statute specifies exploration expenditures as those for "ascertaining the existence, location, extent, or quality of any deposit of ore or other mineral" before beginning of the development stage of the mine or deposit. Exploration expenditures, as thus defined, would seem to include general prospecting over any area to determine whether or not the existence of mineral is indicated in that area, as

well as expenditures for initial exploratory work with respect to any indicated or ascertained deposit.

Whether such expenditures may be subject to the special *exploration* provisions, and to what extent, will be considered later.

Statutory Limitations on Scope of Provisions

Although the statute does not define what may be included in development, it does state certain definite exclusions or limitations with respect to the scope of these provisions which may be noted as follows:

1) Expenditures for depreciable property are not to be included either in development or exploration expenditures, but depreciation allowances to the extent attributable to development or exploration are considered expenditures.

2) The statute specifies that the exploration provisions are not applicable to any expenditure otherwise allowable as a deduction for the taxable year. If, for example, an expenditure for exploration were determined to be worthless and allowable as a loss before the end of the taxable year when the expenditure was made, it would be allowable as a loss in that year and not includible in the expenditures to which the $100,000 limitation applied. If, however, the expenditure were not determined worthless until after the end of the year of expenditure, the loss would not be allowable in that year and the expenditure would be an amount includible within the allowable limitation for the year of expenditure or would be an amount to be capitalized in that year to be recovered through depletion or to be later deducted as a loss when determined worthless. This limitation would seem to exclude from the exploration provisions not only any expenditure determined worthless within the year of expenditure, but also any expenditure allowable as a deduction in that year under any other provision, such as the deductions for ordinary and necessary expenses, research, interest, taxes, etc. (but not depreciation that is subject to the special rule mentioned above).

Similar specification applicable to development expenditures is stated in the regulations.[4] This specification, which is stated in the statute with respect to exploration, is not similarly stated in the statute with respect to development. The Committee Report[5] states, however, that during the production stage the new provision affects only those extraordinary expenditures which under prior law were to be deferred.

If all development expenditures are being currently deducted, it does not seem important to distinguish whether they would be deductible under the development or under other provisions. If, however, election is made for deferment, which must be with respect to the total of the development expenditures for any mine or deposit, it may be important to determine which expenditures are subject to deferment as distinguished from those otherwise deductible.

3) As to net receipts from ores or minerals produced from a mine or deposit during the development period, the statute specifies that an election for deferment shall apply to the excess of development expenditures over such net receipts during the same taxable year. (This is a change from the prior rule, which did not make such a year by year cutoff but allowed the total of such receipts before the end of the development period to be applied against the total of the expenditures to the end of the development period.)

The statute does not specify similar treatment of receipts as applicable to current deduction of development expenditures, and the Treasury's position seems to be that in absence of election the total development expenditures after beginning of the development stage are allowable deductions, and receipts are to be taken up as income year by year. A similar position is taken as to deferments after beginning of the production stage.

As to the exploration expenditures before beginning of the development stage, the statute does not make similar specification with respect to either deferment or current deduction of exploration expenditures. However, by Rev. Rul. 55-430 (1955-2 C.B. 276), the Commissioner has held that in determining the $100,000 allowable statutory deduction or the amount to be treated as deferred expenses for a mine in the exploration stage, the net receipts for the year from sale of ore are to be applied in reduction of the exploration expenditures for the year, so it will be the excess of expenditures over such net receipts that is to be taken into account for deduction or deferment.

If, however, exploration expenditures are to be capitalized (not deducted or deferred), it would seem that the old rule for deduction of aggregate net receipts against aggregate capital expenditures with respect to any mine would still be applicable rather than the new rule of year by year application. This may be more of a theoretical than a practical question, since rarely, if ever, would the net receipts exceed exploration expenditures for any year during the exploration stage.

Disclosure of Ores or Minerals in Commercially Marketable Quantities

This test, which determines the beginning of the development stage and the end of the exploration stage, raises a series of questions:

Disclosure

With the great variance in conditions which may exist in one case or another, it is difficult to prescribe any clear rule for determining when the required existence of ores or minerals "has been disclosed." The few drillholes or the geological evidence that in one case might suffice to disclose existence of commercial ore might be quite insufficient in a different case. In some instances there may be unquestionable evidence when property is acquired that it does contain the commercial ore. In other cases some exploratory work by the taxpayer may be necessary for disclosure. In any event, it may be necessary to rely largely on the opinion of experts or others qualified to express opinion based on evidence available.

What Must Be Disclosed

The required disclosure is "the existence of ores or minerals in commercially marketable quantities."

This is not a requirement that there must be disclosure of the entire commercially marketable quantities that may exist in any mine or other deposit. If that were demanded, few mines would ever pass to the development stage.

Although reference is made in Sec. 615 (b) to deduction of deferred expenditures ratably to "ores or minerals discovered or explored," there is clearly no requirement here for application of the old *discovery* test of a mineral deposit not previously

known to exist which has a value "materially disproportionate to the cost" or that the discovery mineral "could be separately mined and marketed at a profit." Moreover, the test now prescribed is not that of the prior discovery regulations, which refer to a mineral deposit that "exists in quantity and grades sufficient to justify commercial exploitation." The very difficulty of those tests was a reason for abandoning the discovery provisions.

The present test of beginning of the development stage is quite different, both in its wording and its intended scope. To meet this test, it seems sufficient to disclose that minerals in commercially marketable quantities exist, without its being necessary to establish discovery by the taxpayer, value in excess of cost, or quantity or quality as a basis for valuation.

It is not easy to state the exact meaning of the phrase "in commercially marketable quantities," but it seems to be a test of marketability, rather than any of the former tests of discovery.

Required Disclosure as to Mine or Deposit

As this test of beginning of the development period is stated in Sec. 616, it refers to "the development of a mine or other natural deposit." It seems clearly intended that for a mine the test would be with respect to the mine, but that for a deposit which was not or would not be a mine, the test would be applied to the deposit. This intent seems further supported by repeated references in the Committee Report to development of "the mine," etc.[6] Other briefer references in the statute to the "mine or deposit" would seem in no way to change the basic reference to "a mine or other natural deposit" in defining the beginning of the development period.

The proposed regulations[7] would have stated the rule that the test should be applied to "a mine or other natural deposit, whichever is the smaller unit," but this was protested, and such regulations have not been approved. The statute seems intended to consider the mine as the unit if there is or will naturally be a mine and not to break the mine down into separate deposits where the mine may contain a number of veins, lodes, or other deposits. There will undoubtedly be, in some cases, question of what is to be considered "a mine," but this will raise much less difficulty than an attempt to apply the test to each separate deposit which may exist within a single mine.

There may also be question as to what, if any, effect the provisions of Sec. 614 and any aggregation of properties thereunder may have on these development determinations. However, as the exploration and development provisions are written, they seem to contemplate the test as to the "mine or other natural deposit" rather than the technical "property" rules of Sec. 614.

Deductions for Development Expenditures

1) Expenditures During the Development Stage: All expenditures during the development stage which fall within the scope of the development provision are to be currently deducted except as deferment is elected. The taxpayer may each year, and with respect to each mine or deposit, elect to treat as deferred expenses the development expenditures that otherwise might be currently deducted under this provision. The election will apply to the total of such expenditures for each mine or deposit for which the election is made, but the election made for one year or one mine will not apply for any other year or other mine and, as previously noted, the amount for deferment will be after reduction for any net receipts during that year from ores or minerals produced from that mine or deposit.

Such deferred expenses shall be deductible ratably as ores or minerals benefited by such expenditures are sold. Manifestly, the minerals benefited by any expenditure may be only a part of the total minerals in the mine. No attempt can be made here to discuss possible rules for determining what minerals should be considered benefited by any such expenditure or how the ratable amount to be written off each year should be determined. Neither existing nor proposed regulations seem fully satisfactory in that regard.

The technical requirements regarding election, as prescribed by regulations or rulings at any time in effect, must be carefully complied with to make the election valid. Space does not permit their discussion here. In general, the election for each mine or deposit is to be made by clear indication on the return or by statement duly filed not later than the time for filing the return, except as the taxpayer may be allowed 90 days after the applicable regulations are published within which such election may be made for years subject to the 1954 code.

2) Expenditures During Production Stage: Development expenditures after beginning of the production stage will also be currently deductible, whether they are the ordinary development expenditures such as were formerly allowed as current deductions or those extraordinary development expenditures such as were formerly treated as deferred expenses deductible as the minerals benefited thereby were sold. Unless deferment is elected, all such expenditures seem currently deductible.

If deferment is elected, such deferment seems applicable only to the extraordinary expenditures, as previously noted, and the ordinary expenditures would still continue to be currently deductible. Accordingly, the taxpayer might have, for any year for any mine that had reached the production stage, the ordinary development expenditures that could be currently deducted and the extraordinary development expenditures with respect to which he could elect deferment.

Deferment of such extraordinary expenditures would seem subject to the same general provisions as to election and ratable deduction as are applicable to deferred expenses during the development period, with the apparent exception that in the production stage the expenditures to be deferred would not be reduced by receipts from resulting mineral—such receipts then being includible in income.

Deductions for Exploration Expenditures

Except for the permitted allowance to the extent of $100,000 a year, exploration expenditures during the exploration stage are to be capitalized recoverable through depletion ("unless such expenditures produce no useful results, in which case they can be deducted as with any other loss").[8]

Expenditures of not more than $100,000 a year may be currently deducted or may be in whole or in part treated as deferred expenses subject to the further limitations noted below. This $100,000 is

INTERNAL REVENUE CODE OF 1954

Sections 615 and 616

SEC. 615. Exploration Expenditures.

(a) In General. In the case of expenditures paid or incurred during the taxable year for the purpose of ascertaining the existence, location, extent, or quality of any deposit of ore or other mineral, and paid or incurred before the beginning of the development stage of the mine or deposit, there shall be allowed as a deduction in computing taxable income so much of such expenditures as does not exceed $100,000. This section shall apply only with respect to the amount of such expenditures which, but for this section, would not be allowable as a deduction for the taxable year. This section shall not apply to expenditures for the acquisition or improvement of property of a character which is subject to the allowance for depreciation provided in section 167, but allowances for depreciation shall be considered, for purposes of this section, as expenditures paid or incurred. In no case shall this section apply with respect to amounts paid or incurred for the purpose of ascertaining the existence, location, extent, or quality of any deposit of oil or gas.

(b) Election of Taxpayer. If the taxpayer elects, in accordance with regulations prescribed by the Secretary or his delegate, to treat as deferred expenses any portion of the amount deductible for the taxable year under subsection (a), such portion shall not be deductible in the manner provided in subsection (a) but shall be deductible on a ratable basis as the units of produced ores or minerals discovered or explored by reason of such expenditures are sold. An election made under this subsection for any taxable year shall be binding for such year.

(c) Limitation. This section shall not apply to any amount paid or incurred in any taxable year if in any 4 preceding years a deduction or election under this section, or the corresponding provision of prior laws, has been allowed to, or exercised by—

(1) the taxpayer, or

(2) the individual or corporation who has transferred to the taxpayer any mineral property.

Paragraph (2) shall apply only if (A) the taxpayer was required to take into account under section 23 (ff) (3) of the Internal Revenue Code of 1939 the deduction allowed to or election exercised by such individual or corporation; (B) the taxpayer would be entitled under section 381 (c) (10) to deduct expenses deferred under this section had the distributor or transferor corporation elected to defer such expenses; or (C) the taxpayer acquired any mineral property under circumstances which make section 334 (b), 362 (a) and (b), 372 (a), 373 (b) (1), 723, 732, 1051, or 1082 apply to such transfer.

(d) Adjusted Basis of Mine or Deposit. The amount of expenditures which are treated under subsection (b) as deferred expenses shall be taken into account in computing the adjusted basis of the mine or deposit, but such amounts, and the adjustments to basis provided in section 1016 (a) (10) shall be disregarded in determining the adjusted basis of the property for the purpose of computing a deduction for depletion under section 611.

SEC. 616. Development Expenditures.

(a) In General. Except as provided in subsection (b), there shall be allowed as a deduction in computing taxable income all expenditures paid or incurred during the taxable year for the development of a mine or other natural deposit (other than an oil or gas well) if paid or incurred after the existence of ores or minerals in commercially marketable quantities has been disclosed. This section shall not apply to expenditures for the acquisition or improvement of property of a character which is subject to the allowance for depreciation provided in section 167, but allowances for depreciation shall be considered, for purposes of this section, as expenditures.

(b) Election of Taxpayer. At the election of the taxpayer, made in accordance with regulations prescribed by the Secretary or his delegate, expenditures described in subsection (a) paid or incurred during the taxable year shall be treated as deferred expenses and shall be deductible on a ratable basis as the units of produced ores or minerals benefited by such expenditures are sold. In the case of such expenditures paid or incurred during the development stage of the mine or deposit, the election shall apply only with respect to the excess of such expenditures during the taxable year over the net receipts during the taxable year from the ores or minerals produced from such mine or deposit. The election under this subsection, if made, must be for the total amount of such expenditures, or the total amount of such excess, as the case may be, with respect to the mine or deposit, and shall be binding for such taxable year.

(c) Adjusted Basis of Mine or Deposit. The amount of expenditures which are treated under subsection (b) as deferred expenses shall be taken into account in computing the adjusted basis of the mine or deposit, except that such amount, and the adjustments to basis provided in section 1016 (a) (9), shall be disregarded in determining the adjusted basis of the property for the purpose of computing a deduction for depletion under section 611.

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a total allowable to the taxpayer for the year and not an allowance with respect to each property. Such deduction or election of deferment is only allowable for four separate years (not necessarily consecutive) and the four years allowed are to take into account not merely any years for which the taxpayer made such deduction or election, but also any years for which a transferor of mineral property to the taxpayer had made such deduction or election under certain specified situations too technical for detailed discussion here.

It seems recognized that the right of deduction as well as election is optional with the taxpayer, and if that right is not exercised the expenditures are to be capitalized, in which case that year would not be considered one of the four years specified.*

* The proposed regulations in Sec. 1.615-1 recognized that such deduction or election was optional with the taxpayer, and this seems the appropriate rule.

In general, the rules regarding deductions or deferment of exploration expenditures within the applicable limits appear to be substantially the same as for development expenditures during the development stage, except for the differences noted: 1) that deduction as well as election is optional and 2) that within the prescribed limitation the taxpayer may elect to defer all or part of the expenditures for any mine or deposit (and to deduct or capitalize others). There will be the same need for careful attention to any rulings or regulations concerning option or election, with recognition of possible difference in the requirements because of broader options given with respect to exploration expenditures.

Effect on Basis for Property

If development or exploration expenditures are currently deducted, and to the extent that deferred expenditures have become deductible, the expenditures thus deducted manifestly will not form part of the basis for the property for computing gain or loss on sale or exchange of the property or for computing cost depletion. Their effect on percentage depletion computations is later noted.

Deferred development expenses to the extent not yet ratably deductible would increase the property basis for computing gain or loss on sale or other disposition of the property, but not for depletion.

Effect on Percentage Depletion Computations

In computation of percentage depletion allowable for any property for any year, the deduction allowable for that year* for development expenditures with respect to that property is to be taken into account in determining the taxpayer's net income from the property for the purpose of the 50 pct limitation, as is specified in the Committee Report.[5]

* This rule would apply whether the deduction allowable was the current deduction for expenditures in that year or the amount of the deferred expense deduction allowable for that year.

Presumably no percentage depletion would be allowable for any year during the exploration stage, so no exploration expenditures currently deducted would affect percentage depletion computations. The

ratable deductions in later years for deferred exploration expenditures might, however, affect the percentage depletion computations for such later years and be subject to a rule similar to that for development expenditures.

Deduction for Losses

The deduction for loss has two important aspects concerning the development and exploration expenditures here considered: 1) as to when a loss deduction may be allowable with respect to any then remaining balance of expenditures previously capitalized or expenditures previously deferred and 2) as to exploration expenditures which—if allowable as a loss in the same year when the expenditures were made—would not be includible within the $100,000 allowable deduction for that year.

To determine when expenditures for development or exploration are to be deductible as losses because worthless, perhaps the best simple statement of the applicable standard is that in the Committee Report[10] already mentioned, which refers to capitalizing exploration expenditures to be recovered through depletion *"unless such expenditures produce no useful results, in which case they can be deducted as with any other loss."*

There should be no question that if a mining property is abandoned, or if a taxpayer loses or abandons his interest in the property, any amount of capitalized or deferred expenditures not theretofore deductible are then allowable as a loss. If, for example, the taxpayer in any year has made expenditures for exploration or development of property he holds under lease or option, and before the end of that year the lease or option expires or is forfeited, such expenditures should be allowable as a loss to the taxpayer in that year.

However, the loss should be allowable at any time it becomes manifest that the expenditures are worthless for the purpose for which they were incurred. If development work is abandoned or becomes worthless because there is no reasonable expectation of its further utility, or if an exploration project or particular exploration work is abandoned or becomes worthless because there is no reasonable expectation of finding profitable ore, any expenditures therefor not previously deductible should then be allowable as a loss—even though the entire property or the taxpayer's interest therein may not at that time be worthless.

Such standards as these at least approach the standards that should be applied, although they would still leave much room for judgment and opinion in their application.

Expenditures Made by Taxpayer

An important point with respect to the deductions allowable under these sections for exploration or development expenditures is that they are allowable to the *taxpayer who has paid or incurred expenditures* of the type described.[11] If a taxpayer purchases a mine or deposit that has been in whole or in part developed or explored by others at their cost, no part of the cost of that mine or deposit to the taxpayer is to be considered as a development or exploration expenditure by the taxpayer which he would be entitled to deduct or defer under these provisions.

This, however, apparently furnishes no warrant for proposed regulations that if a taxpayer, in consideration for a grant of an interest in the minerals, has made expenditures for exploration or development of the property, such expenditures are not to be considered as deductible under these provisions as exploration or development expenditures by the taxpayer.[12] In such case it is the taxpayer who has made the expenditures of the type described (for exploration or for development) and he seems clearly entitled to their deduction.*

* Note in this connection the specific provisions of Sec. 263 (a) (1) (A) of the 1954 Code (and Sec. 24 (a) (2) of the 1939 Code) which make the general rule regarding capital expenditures inapplicable to expenditures for development of mines; also the statement in the Committee Report (Senate Report No. 781, 82nd Cong., 1st Sess., Part 2, p. 64) that deductions allowable under the exploration section "are not, of course, subject to disallowance under Section 24 (a) (2)."

There seems no departure from the prescribed standard in the specification[13] that a taxpayer who has made expenditures for exploration and development on his property and thereafter leases the property to another continues to be entitled to deduction for the deferred expenditures he has made. Nor is there conflict in the special provisions of Sec. 381(c)(10) which permits an acquiring corporation to deduct deferred expenses of a distributor or transferor corporation under the special situations there referred to, where the acquiring corporation is considered to take the place of the distributor or transferor.

Pre-1951 Expenditures Later Deductible

Expenditures for exploration and development which had been made prior to 1951 seem in no way affected by the new provisions.* Such expenditures, to the extent not previously deductible, would continue their prior status, either as capitalized expenditures recoverable through depletion or deferred expenses deductible as minerals benefited were sold, but, in either case, subject when worthless to appropriate loss deduction.

* The former rules that were applicable to pre-1951 expenditures may be found in Treasury Regulations 111. These rules were later amended by T.D. 6023 (C.B. 1953-2, 132) of June 23, 1953, to state the new regulations for 1951, substantially as these are stated in Treasury Regulations 118 for years beginning after Dec. 31, 1951. As to former rules, see also G.C.M. 13954 (C.B. XIII-2, 66 (1934)).

Further Considerations

This presentation of some of the problems that arise in practical application of these exploration and development provisions leaves many important points unmentioned or incompletely stated. It cannot try to forecast what the new regulations may provide when they are issued or what the decisions of the courts may be as these questions come before them. In the application of these provisions, full consideration must be given to all the technicalities of the statute and there must always be full recognition that the legal interpretation of these provisions and their application as matters of law must come from the attorneys or from the courts.

References

[1] Senate Report No. 781, 82d Cong., 1st Sess., p. 43.
[2] Senate Report No. 781, 82d Cong., 1st Sess., Part II, p. 21.
[3] H. Hoover: *Principles of Mining*, Chap. VII, p. 56. McGraw-Hill Book Co., New York, 1909.
[4] Treasury Regulations 118, Sec. 39.23 (cc)-1 (a) (2).
[5] Senate Report No. 781, 82d Cong., 1st Sess., Part 2, p. 21.
[6] Senate Report No. 781—1951, pp. 43-45.
[7] Proposed Regulations (Federal Register, Nov. 3, 1956) Sec. 1.616-1 (c).
[8] Senate Report No. 781, 82d Cong., 1st Sess., p. 63.
[9] Senate Report No. 781, 82d Cong., 1st Sess., Part 2, p. 22.
[10] Senate Report No. 781, 82d Cong., 1st Sess., p. 63.
[11] Senate Report No. 781, 82d Cong., 1st Sess., Part 2, p. 64.
[12] Proposed regulations Sec. 1.615-1 (b) (3) and Sec. 1.616-1 (b) (3).
[13] Senate Report No. 781, 82d Cong., 1st Sess., Part 2, pp. 22, 64.

Gerhardt mine, Carolina Pyrophyllite Co., Staley, N. C.

Resources and Utilization of North Carolina Pyrophyllite

by Jasper L. Stuckey

PYROPHYLLITE, first identified as soapstone,[1] later as agalmatolite,[2] and finally as pyrophyllite,[3] has been known to occur in North Carolina for more than 130 years and has been produced intermittently in commercial amounts for the past 100 years. Pyrophyllite mining, however, has become a major industry in North Carolina only during the past 25 years. North Carolina and California are the chief producing states. Current annual production averages 125,000 tons, of which slightly more than 90 pct comes from North Carolina.

Distribution and Geologic Setting: All known pyrophyllite deposits in North Carolina are associated with rocks of the Carolina Slate Belt,[4] which is composed of a vast series of metamorphosed volcanic and sedimentary materials, occurring as two zones extending in a northeast-southwest direction across the state. The larger of these zones, lying in the central Piedmont region, varies from 8 to 50 miles wide. The smaller zone lies along the eastern edge of the Piedmont region and is partly covered by coastal plain sediments.

The rocks in both zones consist of a great volcanic-sedimentary series, composed of air-laid and water-laid tuffs and breccias, lava flows, and slates. On the basis of composition, they may be classed into three groups: 1) tuffs, breccias, and lava flows of acid or rhyolitic composition; 2) tuffs, breccias, and lava flows of a basic or andesitic composition; and 3) water-laid slates composed of fine grained materials derived chiefly from the acid tuffs and breccias and

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containing varying amounts of land waste. In the order of abundance, tuffs and breccias are most important, followed by slates and flows.

Of some 15 known occurrences of pyrophyllite in North Carolina, six have been developed enough to indicate important reserves of mineable pyrophyllite. These major deposits occur near Robbins and Glendon, Moore County; near Stanley, Randolph County; near Snow Camp, Alamance County; near Hillsboro, Orange County; and near Oxford, Granville County. All these deposits, with two exceptions, occur along prominent hills or ridges. The Glendon deposit occurs in gently undulating topography, while that near Robbins occurs in a relatively flat area covered largely by a thin veneer of coastal plain sand. All the known deposits appear to occur in acid tuffs and breccias, as none have been found in the slates or basic rock types.

Structure of Deposits: A prominent feature of most pyrophyllite bodies is an irregular, oval, or lenslike form. This structure is observed along the strike and also vertically to the depth reached in mining. In nearly every deposit that has been developed enough to show the true structure, bodies and lenses of pyrophyllite are found along with lenses of tuffaceous rocks that exhibit various stages of alteration. Most pyrophyllite deposits occur as narrow bands or zones aligned with the cleavage strikes and dip of the country rock. The strike of the cleavage in both the country rock and the pyrophyllite bodies is northeast-southwest, while the dip is steeply to the northwest.

In most cases the larger mineralized zones consist of a very siliceous footwall, a well developed mineralized zone, and a highly siliceous and sericitic hanging wall.[3] Where these conditions exist, contacts between the mineralized zone and the footwall and the hanging wall are gradational. Contacts between the footwall and country rock and the hanging wall and country rocks are also gradational. When the footwall and hanging wall are absent, as they frequently are, contacts between mineralized zone and country rock are gradational.

Mineralogy: The mineralogy of the major deposits is relatively simple. Pyrophyllite, the most abundant mineral, occurs as foliated masses, massive granular bodies, and radial fibrous aggregates. The pyrophyllite in the deposits near Glendon and Robbins, Moore County, consists almost entirely of the foliated variety. That in the other major deposits consists largely of massive granular and radial fibrous forms, with occasional small amounts of the foliated variety. Quartz is abundant throughout the deposits except in the very purest pyrophyllite, occurring as large masses of a cherty or milky appearance, as stringers and veins of almost clear material, and as nodules and fine-grained particles. Sericite is often concentrated as bands or zones along the hanging wall of the pyrophyllite bodies and to a lesser extent along the footwall.[3] It is also present as finely divided scales and flakes and as zones through good pyrophyllite. One or more of the minerals diaspore, topaz, andalusite, and kyanite are present in all the deposits except those in Moore County. Andalusite is abundant in the Hillsboro deposit. In the deposit near Oxford there is considerable topaz, some blocks 1 to 2 ft long, as well as amounts of andalusite and kyanite. Chloritoid varies in amount from minor to abundant, while chlorite, pyrite, hematite, and magnetite are common but minor accessories.

Origin of Pyrophyllite: All available field and laboratory evidence suggests that the pyrophyllite bodies were formed through metasomatic replacements[1] of acid tuffs and breccias. Mineralization, however, was not a simple process and probably was accomplished in stages. Following metamorphism, there was considerable silicification along the zones where the pyrophyllite bodies were later developed. Following silicification, pyrite and chloritoid were formed, varying in amounts from minor to abundant. Pyrophyllite was next formed by replacement of the previously silicified tuffs and breccias. Sericite developed along with the pyrophyllite or immediately following. The position of the minerals diaspore, topaz, andalusite, and kyanite in the sequence is not clear, but they appear to have been formed early in the process, as they have been replaced[5] partially by pyrophyllite and sericite. The fact that the mineralizing solutions were of magmatic origin is indicated by small granitic masses that intruded the volcanic rocks, occurring as masses along the western edge of the Carolina Slate Belt.

Reserves: Sufficient evidence is not available to determine accurately the reserves of pyrophyllite in North Carolina, but there is enough information to establish fairly dependable indicated reserves. The writer stated in 1928:[4]

> Taking into consideration the mineralogy and origin of the deposits, the source of the solutions, and the relation in the distribution of the gold and pyrophyllite deposits, it seems reasonable to expect pyrophyllite in commercial amounts to a minimum depth of 500 feet. This statement does not mean that every pyrophyllite prospect can be developed into a mine at that depth. It does mean, however, that all indications point to a depth of that magnitude for the larger bodies which really show promise at the surface.

The results obtained in exploring for pyrophyllite over the intervening years have borne out this statement. Some small prospects have been explored that did not prove continuous in depth, but drillholes more than 500 ft deep have failed to reach the bottom of the major deposits drilled to that depth.

The pyrophyllite deposit occurred as irregular lenses 100 to 500 ft wide and 500 to 2000 ft long or more. The bodies of workable pyrophyllite occur near the center of the deposits and vary in width from 25 to 200 ft. Pyrophyllite has a specific gravity of 2.8 to 2.9 and weighs 175 lb per cu ft. Each 100 ft of length and depth of a pyrophyllite body 100 ft wide should yield 50,000 tons, allowing for a 60 pct recovery. Using these figures and assuming recovery to a depth of 400 to 500 ft, a reserve of some 12 to 14 million tons of pyrophyllite is indicated in North Carolina. It should be pointed out, however, that all these reserves are controlled by four companies operating in the state, and no known deposits are available for new producers.

Mining Methods: Pyrophyllite mining on a commercial basis was started in North Carolina about 1855[2] and has continued intermittently since that time. At first, prospecting and mining were carried out by pits, shallow shafts, drifts, and open cuts. As demands for larger quantities have increased and off-color material has become salable, open cuts —made possible by information from diamond drilling and by modern earth-moving machinery— have furnished most of the production. The largest pyrophyllite mine in North Carolina, the only modern

underground mine, is operated by Standard Mineral Co., at Robbins in Moore County, by a 500-ft shaft, drifts, and stopes.

Processing: Processing of pyrophyllite has changed slowly through the years as demands and uses for the mineral have increased and changed. Prior to about 1855 it was used only locally—for stove linings, fireplaces, chimneys, mantles, and gravestones—and was cut and shaped to fit the particular need. Production of pyrophyllite crayons was started about 1880, continuing until 1922. Ground pyrophyllite was first produced in North Carolina about 1855.[2] From 1855 to 1913 grinding was carried out first at Hancock's Mills and later at Glenn's Mills, both located on Deep River near the present village of Glendon, Moore County. The grinding stock was carefully selected, air dried, and crushed. It was then crushed by hand, ground with millstones, and passed through bolting cloth.

In 1902 the first plant contructed exclusively for grinding pyrophyllite was built near the deposit. This was followed in 1904 by a second plant on another deposit about a mile away. Both plants were alike in that the grinding stock was air dried and crushed. In one plant the crushed material was passed through a hammer mill, ground with millstones, fed into a ball mill, ground 8 hr, and screened. In the other mill the crushed material was ground with millstones, the fines removed by air, and the coarse material fed into a ball mill, ground, and screened. Both plants were abandoned by the end of 1921.

Before 1918 all the known pyrophyllite deposits of any importance in North Carolina were located along the north side of Deep River, in the general vicinity of Glendon, Moore County. In that year, what later proved to be the largest known deposit in the state was discovered about two miles southwest of Robbins, Moore County, when wagon wheels brought up a fine white material that proved to be pyrophyllite. The first modern grinding plant was built on this property about 1921. The process first used consisted of crushing, grinding in a hammer mill, and screening. The hammer mill did not prove satisfactory for fine grinding, and after some modifications the process was discarded. A new process was installed, consisting of crushing, grinding in a roller mill, and screening. As the ceramic market for pyrophyllite has become important, conical pebble mills for fine grinding have been installed in this plant and the other plants in the state.

At present three companies—Standard Mineral Co. at Robbins, Carolina Pyrophyllite Co. at Staley, and Glendon Pyrophyllite Co. at Glendon—are mining and processing pyrophyllite for market. A fourth company, North State Pyrophyllite Co. at Greensboro, is mining pyrophyllite and producing a variety of pyrophyllite refractories but is not selling pyrophyllite as such. None of these companies is carrying out beneficiation or true mineral dressing on crude pyrophyllite. By selective mining, blending, grinding, and screening, a wide variety of grades, standardized both as to grain size and chemical composition, is being produced for fillers and specialty products and for use in ceramic bodies and refractories.

In the processes used to date only pyrophyllite pure enough to make a salable finished product has been used. As a result much good material containing 60 to 75 pct pyrophyllite has been discarded. During recent years, as demands have increased, improved methods of grinding and screening have reclaimed much material formerly discarded. In view of the somewhat limited reserves and increasing demands, too much good material is being left in the ground or thrown on the dumps. The tonnage estimates made are based on the assumption that all material containing 40 to 50 pct pyrophyllite and not too much off-color will be used. During the past two or three years considerable research has been in progress on removal of iron, free silica, and other impurities. The North Carolina State College Minerals Research Laboratory, Asheville, has aided in this program, and a great deal of information not yet in use is being accumulated. On the basis of information now compiled and still being obtained, all indications point to new and improved pyrophyllite milling operations in North Carolina in the near future. Details of the proposed new processes are not yet obtainable, but a large tonnage of pyrophyllite, higher in quality and slightly higher in price than that now being produced, should be made available to industry as demands increase.

Uses of Pyrophyllite: Prior to about 1855 pyrophyllite was used locally for tombstones, and such stones—still well preserved—may be seen in two or more cemeteries near Glendon. Emmons[3] in 1856 described it as an excellent substitute for soapstone in stove linings, fireplaces, chimneys, and mantles. He stated that it was not suitable for paint, as it became translucent when mixed with oil, but described it as a filler that helped retain the perfume in soap and added that large quantities were ground for the New York market in 1855. He described it as suitable for antifriction powder and for use as a cosmetic and quoted Jackson to the effect that it would make a very refractory material for stoneware and crucibles.

At present pyrophyllite is used chiefly for manufacture of insecticides, rubber, ceramics, refractories, plastics, paint, and roofing paper. It has a number of minor uses for products including cosmetics, wallboard, cordage, textiles, bleaching powder, and soap. The best production figures available indicate that about one half the current annual production goes into insecticides and rubber, one third into ceramics and refractories, and the remainder into plastics, paint, roofing, and minor uses.

Uniformity of grain size and mineral content is becoming important for all uses. For ceramics, whiteware, and wall tile, where the size of the finished product must be controlled accurately, pyrophyllite is one of the best materials available, provided it is perfectly uniform in grain size and composition. For use in special refractories, such as car tops for tunnel kilns, monolithic furnace lining, and furnace lining requiring rapid temperature changes, pyrophyllite makes an excellent body that is shock-resistant.

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Case History of the Juniper Prospect

by S. H. Ward and R. A. Barker

THE Juniper Prospect is in Carleton County, N. B., at approximately 46° 31′ north latitude, 67° 20′ west longitude.

During the summer of 1955 an area in west-central New Brunswick was selected for aerial electromagnetic prospecting with American Metal Co.'s helicopter-mounted equipment. Generalized, small-scale government geologic maps had suggested that this area was located along the western border of the northeast-trending granitic backbone of northwestern New Brunswick and might be underlain by the Ordovician-Silurian sediments and volcanics that are the host rocks for the recently discovered sulfide deposits of the Bathurst-Newcastle district.

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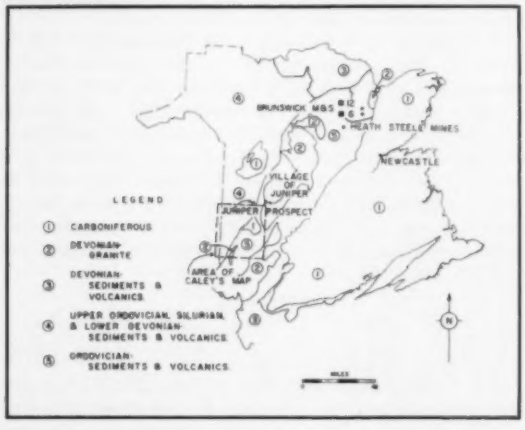
The helicopter electromagnetic equipment located an anomalous conductive area, coincident with a small aeromagnetic closure, about five miles west of the town of Juniper.

Subsequently 30 mining claims (total area about 6600 x 8000 ft) were staked and company personnel conducted geological, geophysical, and geochemical investigations on the property. The claims and immediately contiguous areas were mapped geologically, and an area of about 2000 x 4000 ft was soil-sampled and also surveyed by ground electromagnetic and gravity methods. Finally six diamond drillholes, totaling 3500 ft in length, were drilled to test the anomalous conditions discovered by the several exploration techniques used.

The discovery of base metal sulfides during drilling was a technical success for the exploration methods, but the quantity of sulfides was too small to be profitably exploited.



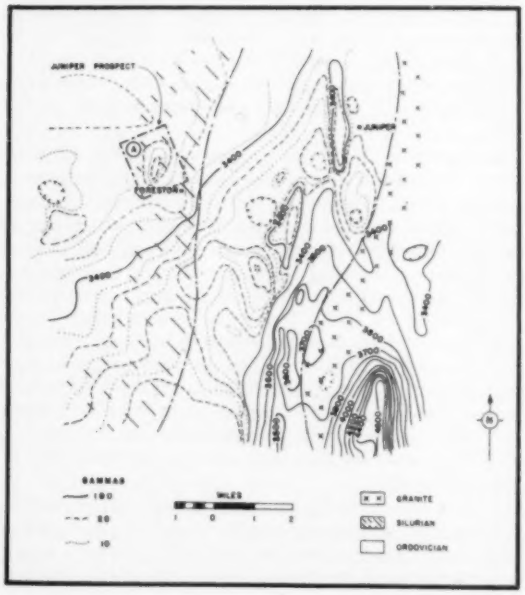


Fig. 1 (above)—Generalized geologic map of New Brunswick (after G. S. C.). Fig. 2 (right)—Map showing aeromagnetic contours with superimposed generalized geology of area near Juniper Prospect (after G. S. C.).

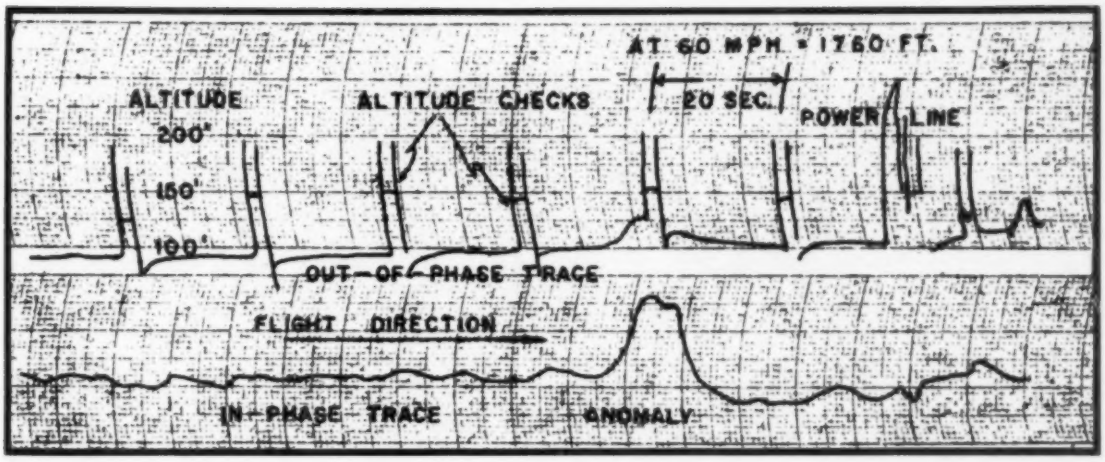


Fig. 4—Typical helicopter EM trace.

Geology: No published geologic maps of the Juniper area are available, with the exception of the Geologic Map of the Maritime Provinces (see Fig. 1) on a scale of 1 in. to 12 miles. The area immediately to the southwest has been mapped by Caley on a scale of 1 in. to 2 miles.[3] Projection of Caley's units some three or four miles northeastward suggests that the Juniper property is underlain by Silurian slates in contact with Pre-Silurian quartzites and slates to the east. The western border of the main granitic core of New Brunswick lies about five miles to the east of the Juniper Prospect.

Claim lines, streams, roads, and grid picket lines were traversed during geologic mapping, see Fig. 3. Relief on the property is not more than 50 ft and swampy areas are numerous and extensive.

Outcrops are confined to the stream that traverses the northeast corner of the property and to the road that parallels the southern boundary. Almost no outcrop was found in the central grid area, but float was considered to be representative of bedrock. Both float and outcrop indicate that the whole property is underlain by a monotonous sequence of slates and argillites varying slightly in sand content but essentially of similar composition. No structures other than bedding and cleavage or jointing were observed, although it is possible that strata may be repeated in the area by steep isoclinal folding. Strikes vary slightly about a north-east direction and both bedding and cleavage dip steeply to the east. No evidence of faulting was observed. Sulfide minerals were not seen either in float or outcrop.

Geochemistry: Approximately 1000 soil samples were collected in a grid pattern over an area 4000 x 4600 ft. Samples were taken by soil auger at a depth of about 2 ft and were spaced at 100-ft intervals along lines 200 ft apart. Samples were unobtainable at a number of places because of swamps.

All samples were analyzed for copper and zinc, using the well known dithizone colorometric method after digestion with hot nitric acid. Several scattered above-normal zinc values were recorded, but no larger anomalous areas were outlined.The geochemical results were, therefore, interpreted as being essentially uninteresting.

Helicopter and Ground Electromagnetic Data: The reconnaissance helicopter electromagnetic (HEM) survey, on flight lines spaced ¼ mile apart, located a response on one line passing directly over the aeromagnetic anomaly marked *A* in Fig. 2. Subsequently, several other flights were made at close intervals and the peaks of the HEM anomalies so registered are shown in Fig. 3. The correlation between the HEM and aeromagnetic data appears to be fairly good. A typical HEM trace over this conductor is shown in Fig. 4.

Following detailed geologic examination of the area of the combined HEM and aeromagnetic

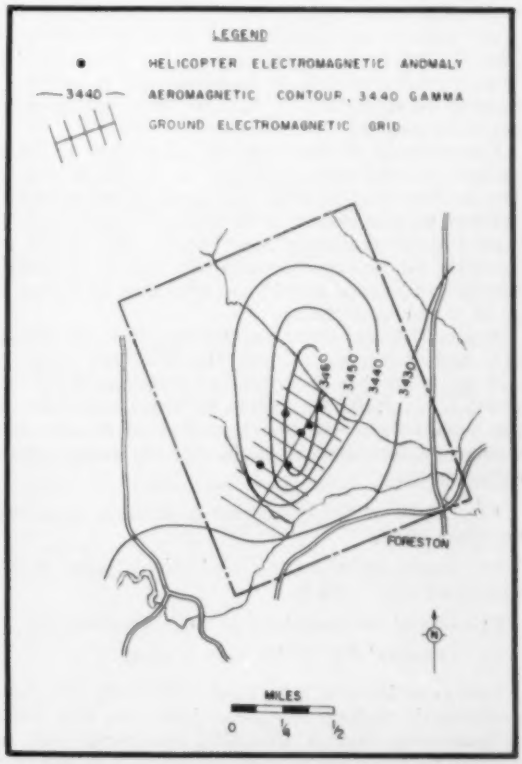


Fig. 3—Map showing aeromagnetic and helicopter EM anomalies at Juniper Prospect.

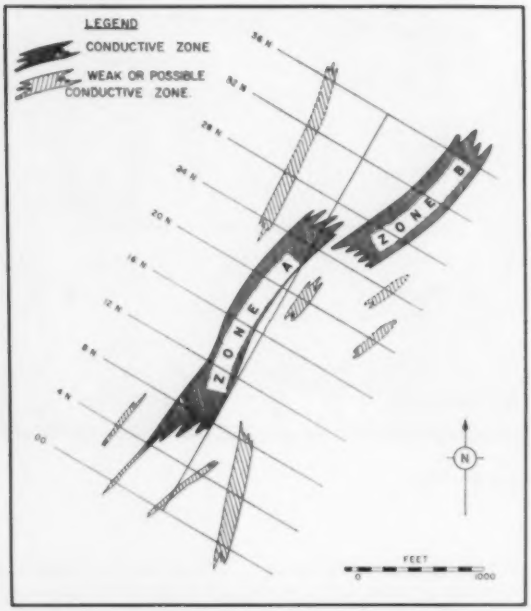


Fig. 5—Map showing conductive zones outlined by ground EM survey.

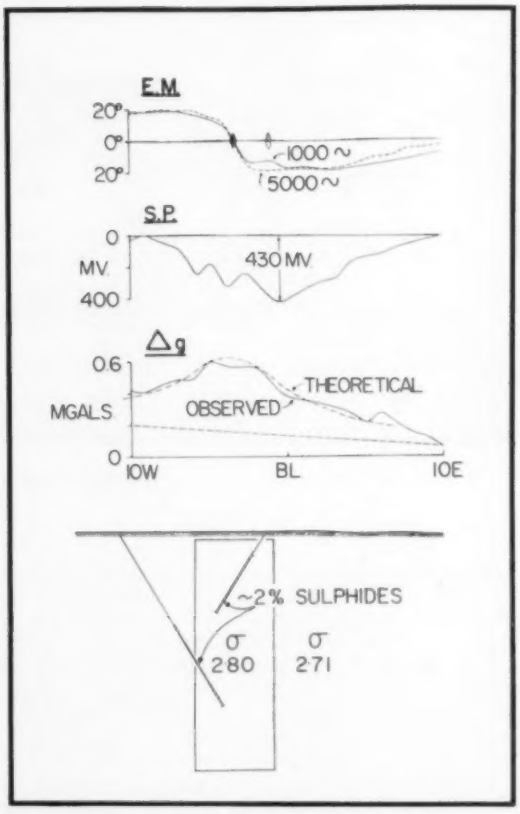


Fig. 6—Section (facing north) showing EM, SP, and gravity profiles on line 16N.

anomalies, a ground electromagnetic (EM) survey was carried out using the McPhar dual-frequency vertical coil technique. Fig. 5 indicates the conductive zones delineated by this method. One broad prominent zone parallels the geologic strike throughout the grid area and several weaker zones or possible zones exist to the east and west of it. The broad zone would appear to be offset by faulting or tight folding in the region of line 25N. This might be accounted for by a fault, striking N45°W and paralleling topographic linears in the area, but no other evidence supports this structure.

For purposes of discussion the broad zone has been subdivided into parts *A* and *B*, as shown in Fig. 5. The conductivity of zone *A* is good at the northern extreme and decreases to fair in the southern portion. Zone *B* exhibits good conductivity in the vicinity of line 24N, but this decreases to fair northward. Other conductors located within the grid area appeared to be of minor importance.

Typical EM *dip angle* profiles are shown in Fig. 6. The dashed curve indicates the 5000-cps response and the solid line the 1000-cps response; the ratio of the areas under the curves provides a measure of the conductivity of the causative body. In this instance, interpretation of the EM dip angle profile indicates that:

1) Depth of the conductor is shallow, probably less than 50 ft.

2) Depth extent of the conductor is large, probably more than 1000 ft.

3) Dip of the conductor is steeply eastward.

4) Conductivity of the body is good.

Past experience in New Brunswick with this electromagnetic survey technique indicates that most carbonaceous and/or graphitic sediments are of moderate to poor electrical conductivity, whereas most massive sulfide bodies, especially those containing pyrrhotite, are of good to excellent electrical conductivity. Exceptions to this rule have been noted, mostly where intense shearing of graphitic sediments produces good to excellent conductors. While massive sulfide bodies show good to excellent electrical conductivity, disseminated bodies range from very poor to excellent conductors depending upon the amount, type, and distribution of mineralization.

Thus the EM survey, by conductivity analysis alone, places this conductor in an interesting category. This information, together with the knowledge (derived from the aeromagnetic data) that the conductor is directly or indirectly associated with magnetic minerals, leads to the conclusion that pyrrhotite is the most logical common cause. The combined magnetic and electromagnetic anomalies might be explained, of course, by graphitic sediments interbanded with magnetic iron formation, but the limited areal extent of the aeromagnetic anomaly is against this.

Since there was no outcrop in the immediate area of the grid and no mineralized float was seen during geologic reconnaissance, completion of a gravity survey before drilling appeared to be the next logical step. The gravity survey would be expected to determine whether or not a significant amount of excess mass was directly associated with the EM conductors. A large, sharp gravity anomaly directly over the EM conductors might be interpreted as a representation of a substantial tonnage of massive sulfides.

In the course of the geophysical investigations, a self-potential profile was obtained along line

16N. For comparison, this profile is shown in Fig. 6, along with the EM and gravity profiles.

Gravity Survey Data: When a gravity survey was applied to this property, the basic assumption was made that the excess mass sought came to within about 50 ft of surface and dipped steeply. A sharp gravity feature would be expected, therefore, from any substantial tonnage of near-surface excess mass, and the gravity survey could be limited initially to a small area. Consequently the area covered was only 2000 x 2400 ft. The observed gravity contours over this area are shown in Fig. 7. A density of 2.65 gms/cc was assumed in applying the Bouguer correction. No correction was necessary for terrain.

From Fig. 7 it may be seen that the observed gravity contours create a domed surface of maximum relief 0.60 mgals over the area surveyed. The peak of this broad anomaly falls along zone *A*. Most of the anomaly may be attributed to a deep-seated source or, alternatively, to a diffuse and shallow one. It does not appear to reflect the large near-surface excess mass that was sought.

The gravity data might be explained by a deep-seated large massive sulfide body, but stringers would have to extend from such a body to surface to account for the conductors located by the EM survey. Alternatively, a small disseminated sulfide body might exist near surface.

To emphasize the near-surface effects and provide targets for drilling based on the latter alternative, a second-order surface was removed from the observed contours of Fig. 7 (least square fitting of second-order surface). The residual contours of Fig. 8 result. A small anomaly of about 0.15 mgals centered about 2+00W line 16N is the most striking feature remaining. This anomaly coincides, at least in part, with conductive zone *A*.

Although the gravity survey data tended to downgrade this prospect as an economic possibility, some drilling appeared to be warranted. Drilling was recommended to test the shallow ore possibilities and to provide a brief test of the deep ore possibilities.

Drilling Results: Of the six holes diamond drilled in the grid area, five were 300 to 600 ft long and one was 1300 ft long.

Diamond drilling confirmed the interpretation of the general geology of the prospect gained from surface mapping. All the core is composed of argillaceous sediments, varying in color from predominant gray, through green and black, to red and reddish brown. Minor variations in composition are shown by more sandy and quartzose layers. Although the black slates are doubtless carbonaceous, none are highly graphitic and therefore not conductive as proven by tests with an ohmmeter. Metamorphic grade is very low; chlorite is present but no biotite was observed in the hand specimen.

Many quartz and quartz-carbonate veinlets (averaging ⅛ to ¼ in. wide) form stockworks throughout much of the core. In a number of places there is a slight bleaching adjacent to these veinlets.

Highly contorted bedding (?) surfaces and the presence of sedimentary fragments in a similar matrix are possible evidence of primary slumping and pre-lithification deformation.

All cores contained minor disseminated pyrite and marcasite (?) especially in the darker sediments, as well as pyrite, pyrrhotite, and some chalcopyrite, sphalerite, galena, and arsenopyrite in very small ramifying veinlets, which form stockworks similar

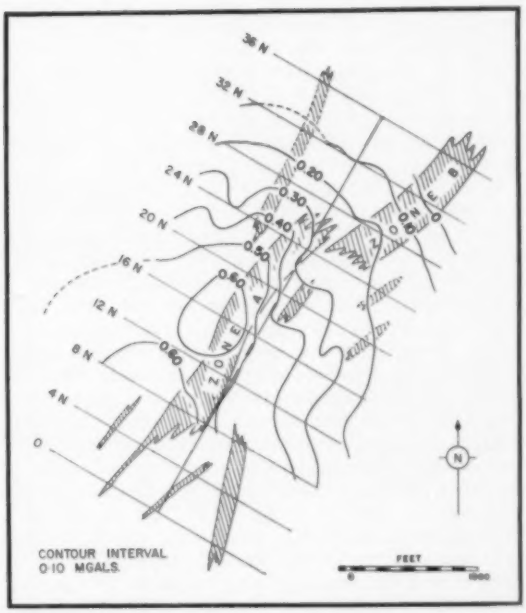


Fig. 7—Map showing observed gravity contours in relation to conductive zones.

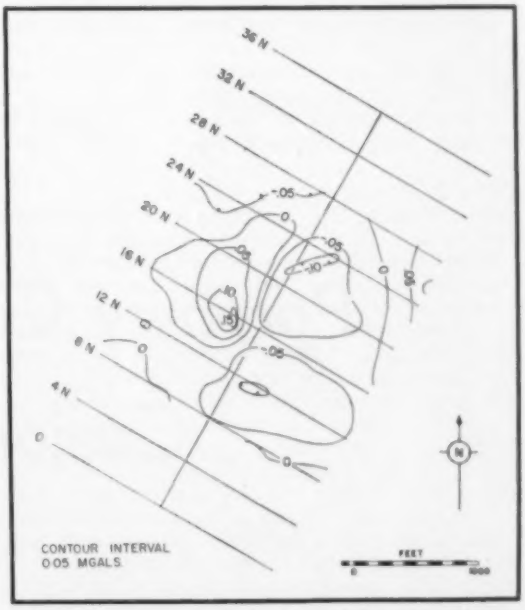


Fig. 8—Map showing second-order residual gravity contours.

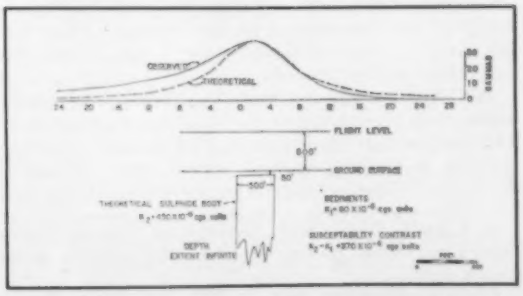


Fig. 9—Section (facing north) showing comparison of theoretical and observed aeromagnetic anomalies.

to the quartz-carbonate stockworks and in some places coinciding with them. The sulfide veinlets range from about 1/16 in. to 1 in. wide and average about ⅛ in. wide. They appear to have been emplaced along fracture or joint planes. The stockworks are confined to zones intersected in the holes, but these zones do not have noticeable stratigraphic or structural boundaries.

The quantities of base metals contained in these veinlets are insignificant from an economic viewpoint, but they appear to be an adequate explanation of all the geophysical data. The minor pyrrhotite, because it is of excellent conductivity and occurs in a stockwork, readily explains the EM data. There seems to be enough pyrrhotite mineralization to cause the small aeromagnetic anomaly and enough total sulfides to cause the gravity anomaly. Measurements on many samples of diamond drill core showed that any anomalous density or magnetic susceptibility could be directly attributed to pyrrhotite. The unmineralized argillite was found to be amazingly uniform, having a density of 2.71±.04 gms/cc and a magnetic susceptibility of 80×10^{-6} cgs units (based on measurements on 91 samples). The argillite mineralized with pyrrhotite showed densities up to 3.28 gms/cc and susceptibilities up to 6700×10^{-6} cgs units.

As a final check on the adequacy of the drillhole data as an explanation of the geophysical data, the gravity and magnetic anomalies due to masses of dimensions and characteristics shown in Figs. 6 and 9 have been computed. The comparisons of theoretical and observed anomalies suggest that the assumptions for the theoretical models are in reasonable agreement with the results obtained by drilling.

A density contrast of 0.09 gms/cc is required for the body used to compute the theoretical gravity profile. Four percent sulfide (density 5.0 gms/cc) in argillite of density 2.71 gms/cc would provide this density contract. A susceptibility contrast of 370×10^{-6} cgs units is required for the body used to compute the theoretical aeromagnetic profile. This could arise from approximately 2 pct pyrrhotite in argillite of susceptibility 80×10^{-6} cgs units, assuming a susceptibility for massive pyrrhotite of $18{,}000 \times 10^{-6}$ cgs units. The above percentages of sulfide mineral content are in good agreement with a visually estimated 2 to 4 pct total sulfides in drill core.

Conclusion

Prior to drilling, the summation of all geological and geophysical data indicated that the possibilities for commercial mineralization on this property were meager. However, a limited drilling program appeared to be warranted and was carried out. Drilling results corroborated the geological and geophysical interpretations. Consequently it is believed: 1) that enough drilling has been carried out and 2) that a commercially exploitable ore deposit is not likely to exist on the property.

Acknowledgments

The authors wish to thank the management of American Metal Co. Ltd. for permission to publish this article. Constructive criticism and encouragement from various members of the exploration division of the mining and exploration department is gratefully acknowledged.

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Porphyry Copper Deposit Cuajone, Peru

by W. C. Lacy

THE Cuajone porphyry copper deposit is the northernmost of a group of three deposits in southern Peru controlled by the Southern Peru Copper Corp.—Toquepala, Quelleveco, and Cuajone—all within a 20-mile belt.

Although small pockets of high-grade copper oxide ores were worked in the Cuajone area in the 19th century, it was not until 1939 that its potentialities as a disseminated deposit were recognized by O. C. Schmedeman. An exploratory drilling program was begun in December 1942 and continued until early 1945. The program was revived in November 1952 and completed early in 1954. Early exploration was by diamond drilling. Later exploration was predominantly churn drilling, with diamond drilling used only for wildcat holes.

Along this northwest-trending belt of deposits, which follows the western slopes of the Andean Range, quartz-monzonite has invaded earlier diorite intrusives and a series of warped and tilted Cretaceous(?) volcanic flows. Little faulting of consequence has been recognized within the mineralized areas. Sulfide minerals were introduced into all these diverse rocks, and mineralization was followed by erosion, oxidation, and enrichment. In Late Tertiary and/or Quaternary time the entire

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area was blanketed beneath volcanic flows, agglomerate, and ash.

Streams fed by glacial meltwater cut deep canyons through these volcanics and in the Cuajone area exposed a narrow belt of leached capping in the Chuntacala Valley and a wide halo of alteration in the Torata and Cocatea valleys (Fig. 1). Spurs between the valleys are relatively flat, westward-dipping plateaus capped by the post-ore volcanics. Outcrops of the underlying older rocks are scarce and the geology must be largely interpreted from drilling data.

The Cuajone quartz-monzonite porphyry stock is roughly 6500 ft long and 3500 ft wide. The long axis strikes northwest, and both lateral contacts dip steeply to the northeast. It invades an earlier diorite intrusive and a sequence of southwestward-dipping Cretaceous(?) volcanic flows which include: an andesite porphyry (not reached by any drillholes in the vicinity of ore mineralization); a basalt, with olivine-rich phases; an overlying rhyolite porphyry and a second andesite porphyry capping the rhyolite porphyry. These volcanics lie unconformably on Cretaceous quartzite, shale, and coal beds exposed in valleys north of the Cuajone area. Post-ore latite porphyry dikes, and breccia dikes or breccia pipes, which appear to be genetically related to the latite porphyry, cut mineralized quartz-monzonite and the warped volcanics.

Table I. Summary of Geological Events

Quaternary to recent:	Alluvium	
Tertiary to Quaternary:	Volcanics	
	Volcanic ash	
	Agglomerates	
	Vitrophyres	
	Andesite porphyry flows	
	Rhyolite porphyry flows	
Erosional unconformity. Period of oxidation and enrichment.		
Tertiary (?):	Intrusive Series	
	Breccia dikes	
	Latite porphyry dikes	
Period of sulfide mineralization. Copper introduced late.		
Tertiary (?):	Breccia pipes	
	Quartz-monzonite porphyry stocks	
	Diorite and quartz-diorite stocks	
Period of mild folding and tilting to the southwest.		
Late Cretaceous (?):	Volcanics	+ 3000 ft
	Andesite porphyry	0 to 350 ft
	*Rhyolite porphyry	± 1000 ft
	Basalt (olivine)	± 2000 ft
	Andesite porphyry	?
Cretaceous:	Sedimentary Rocks	
	Quartzite, shales, coal	?

* Probably equivalent to the Quelleveco quartz-porphyry.

Breccia pipes and shatter pipes* belonging to an earlier generation cut the quartz-monzonite porphyry stock and Cretaceous(?) volcanics and appear to have localized ore mineralization.

A possibly still earlier generation of breccia, observed along the northern portion of the Cuajone stock, was solidly cemented by quartz, tourmaline, and minor sulfides. Tourmaline is rare in the later breccias.

Shape: The principal orebody, the Chuntacala, comprised essentially of primary sulfides, is located on the southern nose of the northeastward-dipping Cuajone quartz-monzonite stock. Drilling revealed it to be roughly circular in plan, about 3000 ft diam

* The term *breccia pipe* refers to a pipe-like body of brecciated rock in which the rock fragments have moved generally upward and have been rotated. *Shatter pipe* is used to refer to a pipe-like zone of strong shattering of the rock, but with apparently little movement of the rock fragments vertically and little rotation in place.

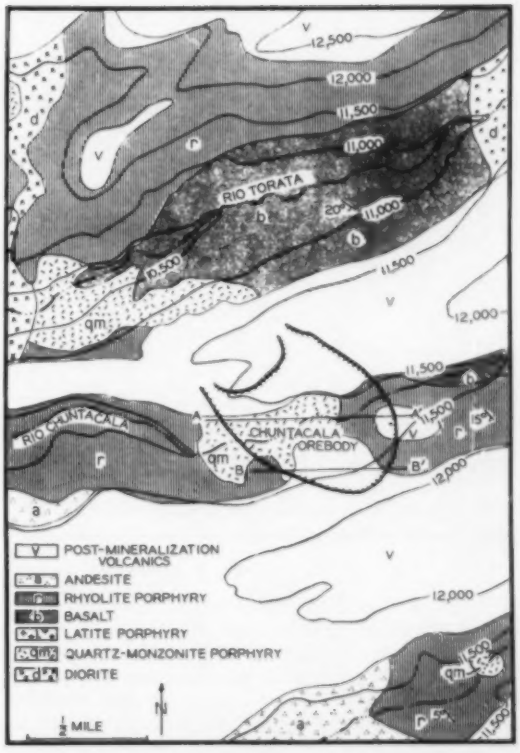

Fig. 1—Geological map of Cuajone area.

near the surface. It has two irregular horn-like extensions to the northwest, not yet explored in detail, which follow the contact between volcanics and intrusive. With depth the orebody divides into two distinct roots, shown in Figs. 2 and 3. The northern portion tapers downward as an inverted cone with an elliptical plan; at a depth of 1600 ft below the bottom of the valley it runs 650 ft in an east-west direction and 1300 ft north-south. The southern portion follows down the south contact zone of the quartz-monzonite intrusive as a tapering figure with a crescentic plan. Drillholes were stopped in primary ore at a depth of 1935 ft below the valley within these roots. The ore occurs within the quartz-monzonite and the warped volcanics.

Ore Mineralization: Sulfides within the orebody occur as small veinlets up to 2.5 in. wide but usually 0.5 in. wide or less in closely spaced array. Rock fragments between the veinlets contain disseminated sulfide grains. Pyrite is the most abundant of the sulfide minerals, chalcopyrite the principal primary ore mineral. Minor quantities of bornite, galena, sphalerite, and enargite were noted in cores and sludge samples. Molybdenite is common but spotty in its occurrence associated with quartz veinlets and as fracture coatings. Supergene enrichment processes have formed chalcocite and covellite. Chrysocolla, cuprite, tenorite and local concentrations of native copper have formed where the zone of oxidation has encroached upon enriched ore.

There appears to be a general increase in abundance of lead and zinc minerals toward the outer portions of the ore zone, but economically they are of little importance, and no quantitative data regarding their distribution was obtained. A study

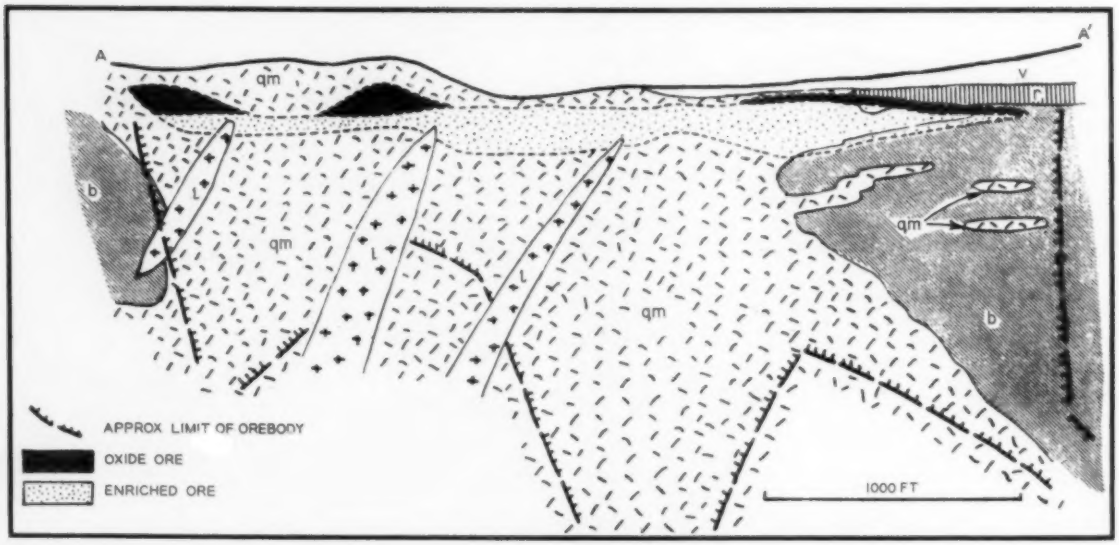

Fig. 2—Cross section through central portion of Chuntacala orebody.

indicates that in and around the Chuntacala orebody the ratio of iron to copper in the sulfides varies. Within the central pipe portion of the orebody and close to the contacts of the intrusive stock the copper/iron ratio is high and a small percentage of sulfides indicates high copper values. On the outer fringes of the mineralized area the ratio is low, and even a high percentage of sulfides does not promise ore grade. This zoning was important in interpreting geophysical results obtained using pulse methods.[1]

Wallrock Alteration: The course of chemical changes that took place in the wallrock related to the processes of ore deposition varied with the initial chemical composition of the altered rocks. However, the ultimate products of intense alteration were the same irrespective of the nature and composition of the original rock.

Wallrock alteration at Cuajone is similar to that generally described as characteristic of the porphyry-copper deposits of the western U. S. Evidence can be observed on both small and large scales for expanding fronts of alteration, each being displaced outward by a higher intensity phase emanating from fractures or channelways. On a small scale in the quartz-monzonite or rhyolite porphyry, sulfide veinlets may be flanked by zones rich in secondary quartz, grading outward through sericite and quartz into a clay-sericite mixture, and finally a broad argillized zone. The same pattern holds on a broad scale: areas of strong silicification and sericitization (intense alteration) grade outward into areas of mixed silicification, sericitization, and argillation (moderate alteration) and this in turn into a broad zone argillation (weak alteration). In basalt the alteration follows the same general pattern, but a wider variety of alteration minerals is formed in the lower intensity zones. These include serpentine, talc, chlorite, and clay minerals. Zones of intense alteration in the basalt are characterized by quartz and sericite but may also contain minor quantities of epidote.

A zone of weak to moderate intensity alteration of the rock around the Chuntacala orebody forms a halo about a mile and a half wide. Areas with high intensity alteration are generally confined to the immediate area of the orebody but only partially conform to the ore distribution pattern, as shown in Fig. 4.

Controls of Ore Localization: Future geological mapping of the open pit areas will reveal the complex nature of the structure that can only be generally surmised from drilling data. However, control of ore localization appears to be principally structural in nature, with copper values concentrated along zones of shattering or brecciation that were open at the time copper-bearing solutions were introduced. Where structures transcended rock boundaries, rock types exerted minor control as to the grade of copper values.

Within the southern portion of the quartz-monzonite porphyry stock there appears to be a cluster of breccia pipes adjacent to which the rock has been severely shattered. The number and extent of these pipes is not known. These apparently have served to localize ore values. Alteration of the wallrock in the vicinity of this supposed pipe cluster is generally only of moderate intensity.

A zone of irregular shattering and brecciation occurs adjacent to the contact area between quartz-monzonite and volcanics affecting both. This zone is best developed around the southern nose of the stock, and ore mineralization related to this feature seems to merge with that of the breccia pipe cluster

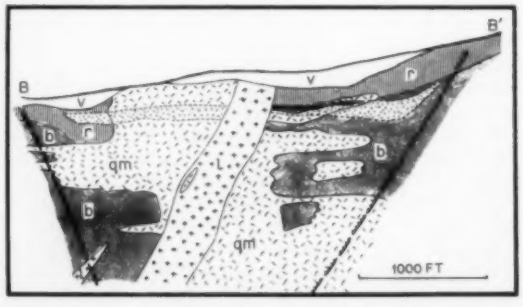

Fig. 3—Cross section through southern portion of Chuntacala orebody.

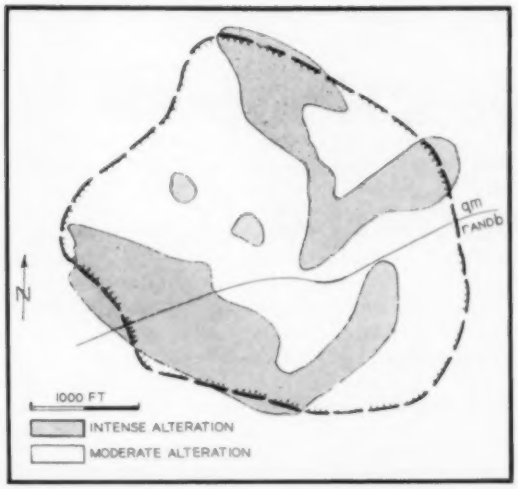

Fig. 4—Plan of Chuntacala orebody showing alteration intensity.

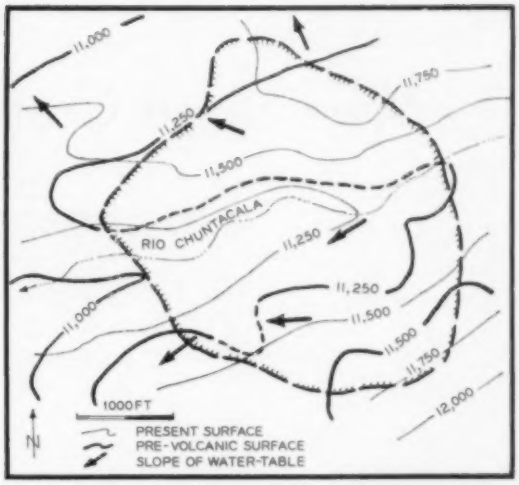

Fig. 5—Plan of Chuntacala orebody showing relations between present surface, pre-volcanic surface, and present water table.

in the upper levels. Intense wallrock alteration accompanies mineralization localized along this structure.

In places where drillholes cut down through alternating quartz-monzonite porphyry and basalt, control of ore grade by rock type is striking. Copper values are generally 0.1 to 0.2 pct higher in the basalt; in only a few instances was there no change or reversal. The rhyolite porphyry appears to react chemically in the same fashion as the quartz-monzonite porphyry.

Oxidation and Enrichment: Construction of contours, based on drillhole data, of the Pre-Tertiary—volcanics land surface, depth of oxidation, depth of enrichment, location and thickness of the oxide ores, and configuration of the present water table yielded interesting data regarding oxidation and enrichment of ores in the Chuntacala orebody.

At the time of extrusion of the Late Tertiary(?) or Quaternary flows and deposition of clastics the topography in the area of the Chuntacala orebody was one of considerable relief—approximately 600 ft in the immediate area of the Chuntacala orebody. Valley and ridge areas did not conform with present topography. This old topography appears to exert a greater influence upon present subsurface drainage and the resultant water table configuration than does the present topography. (See Fig. 5).

The top of the zone of enrichment in the southern and central portions of the Chuntacala orebody faithfully approximates this pre-volcanics erosion surface, being only a few feet below the surface in the valley areas and under about 200 ft of leached capping in the ridge areas. In the northern portion of the orebody the pattern is confused, with no apparent relation to present ore pre-volcanics erosion surfaces. Proximity to the deeply eroded Torata Valley and rapid fall-off of the water table in this direction may have resulted in deep oxidation and leaching along permeable fractured zones.

The bottom of the enriched zone is irregular and does not parallel either present or pre-volcanics erosion surfaces. Locally it extends to more than 160 ft in narrow roots; elsewhere there is no enrichment. Depth of secondary enrichment appears to be a function of rock permeability, with shattered and brecciated zones permitting deeper phreatic circulation, and is seemingly unrelated to rock type or wallrock alteration.

Oxide ores of the Chuntacala orebody are located principally upon the pre-volcanics ridges and appear to be due to encroachment of oxidation on the enriched zone in pre-volcanics time.

Acknowledgments

Many geologists have contributed to the present understanding of the Cuajone district which is briefly summarized above. Particularly important are the contributions of W. R. Bacon, J. D. Hamilton, John Livermore, G. C. Amstutz, J. R. Bogert, and P. R. Eakins. Permission to publish this article was granted by Southern Peru Copper Corp. and Cerro de Pasco Corp.

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[1] A. A. Brant: The Role of Geophysical Methods in Modern Exploration Programs. *Engineering and Mining Journal*, Mining Guidebook, mid-March 1955, p. 32.

Discussion of this paper sent (2 copies) to AIME before Feb. 28, 1958, will be published in MINING ENGINEERING.

Correction

Grinding Practice at Tennessee Copper Co.'s Isabella Mill. By F. M. Lewis and J. E. Goodman. (MINING ENGINEERING, November 1957.) Page 1253, Col. 2, paragraph 1 beginning line 10 should read: "Actual costs of carrying out this plan are tabulated in column 3. It will be seen that these costs follow the estimates in column 2 very closely." Line 16 of the same paragraph should read: "operating cost in column 3." Page 1255, line 2 under Conclusions should read: "13 pct more efficient."

Mineralized Cretaceous Horizons in Northeastern Mexico

by P. Sanchez-Mejorada

GEOLOGISTS who are acquainted with the mines of northeastern Mexico realize that the most important lead-silver replacement deposits of the province are confined to a single formation. But since the formation is several hundred meters thick, the author has determined the relative position of the lead *mantos* in the belief that this information will prove useful in the search for new mines.

This article describes the stratigraphic location of lead-silver replacement deposits known in several mines situated in a region comprising part of the states of Coahuila and Nuevo Leon. The area studied extends for 200 km* (125 miles) from east to west and 70 km (45 miles) north to south.

* Conversions of metric units to English units are approximate.

Metallogenic Province: The most important metallic deposits of the region have the following common characteristics:

1) The orebodies occur as *manto* replacements of calcareous sediments.

2) The horizons that have contributed large tonnages of ore are in similar positions in the corresponding stratigraphic columns (as it will be shown later on).

3) Lead is the most important metal in the ores. Silver is commonly present in small amounts. Occurrence of zinc is dependent on the degree of oxidation of the primary sulfides.

4) A large proportion of the total production has been in the form of oxidized ores.

5) The deposits are located on anticlines.

Rocks of Cretaceous age crop out over large areas of the states of Nuevo Leon and Coahuila, forming part of a belt that extends to the south along the eastern Sierra Madre. The sediments are cut by a small number of intrusive stocks ranging in characteristics from rhyolite to diorite.

The most prominent structural feature of the region is a series of folds trending northwest-southeast. Faulting is not conspicuous in the region, although a major fault zone is found farther East.[1]

The physiography closely reflects structural features, with mountains formed by anticlines and valleys conforming with intermediate synclines. Narrow valleys have also been developed along the axes of many anticlines, where solution of limy sediments and erosion have proceeded along axial tension fractures.

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TP 4680I. Manuscript, March 18, 1957. New Orleans Meeting, February 1957.

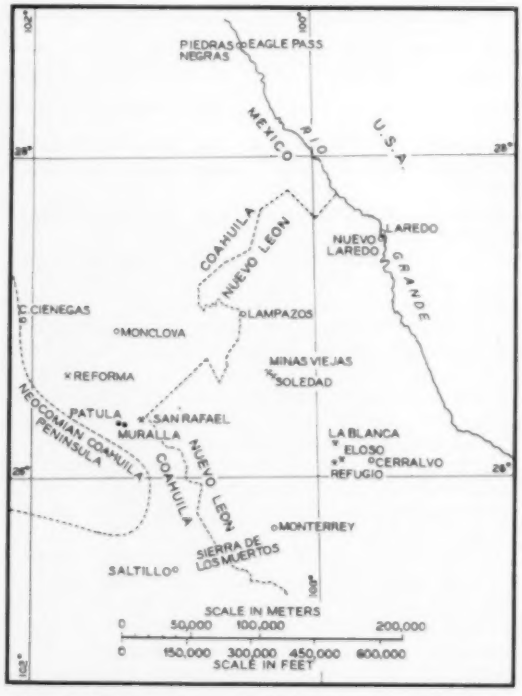

Fig. 1—Location of several lead mines in northeastern Mexico.

Stratigraphy: Rocks of the Upper Cretaceous are exposed in only a small percentage of the total area. Generally they have been eroded away from the mountains and are covered by recent talus and alluvium in the valleys.

Humphrey[2] has published an excellent paper describing the Cretaceous formations of the Sierra de los Muertos, a short distance west of Monterrey. A brief summary of these formations is given below to convey an overall picture of the stratigraphic sequence that prevails just south of the area under consideration.

Upper Cretaceous

Indidura: Essentially thin shaly sediments.

Cuesta del Cura: Limestone in thin wavy beds

with black chert. This formation marks the transition from lower to upper Cretaceous.
Lower Cretaceous.

Aurora Limestone: Gray, massive limestone in thick to medium beds.

La Pena: Formation rich in cephalopods and composed of marls and shales interstratified with thin beds of shaly limestones and bands of black chert. Humphrey applies the term *La Pena* to only a fraction of the formation originally described under this name by Imlay.[5] Humphrey's classification is used in this article because this restricted section forms a very distinctive unit in the region.

Cupido: Medium to thick-bedded limestone with dolomitic beds that are more abundant toward the base of the formation.

Taraises: Limy-shaly sediments and thin limestone beds.

The upper portion of this stratigraphic sequence prevails without important variations throughout the region, but there are radical changes in the pre-Cupido formations.

The soft Indidura sediments are commonly found only as narrow belts along the foothills of the mountains. The Cuesta del Cura limestone is not prominent in general, and it may be absent.

The Aurora limestone forms the most extensive outcrops and the top of the formation often outlines the mountains.

The sediments of La Pena form a thin band of soft rocks that are more easily eroded than the adjoining hard limestones. This fact is reflected in the topography and the vegetation, affording an excellent marker throughout the region.

The Cupido formation is very similar to the Aurora, except for the presence of dolomite beds in the former. The dolomites are believed to be of marine origin, although some dolomitization has been recognized as being related to the mineralizing processes.

A section measured by the author in the San Lazaro canyon, along the Saltillo-Monclova highway, shows that the Cupido formation with typical dolomitic beds is 295 m (970 ft) thick, and that the lowest 45-m (150-ft) unit includes many dolomite beds and interbedded shales. This formation rests on detrital strata that correspond to the top of the *Patula Arkose*.

The *Patula Arkose*, which attains a thickness of more than 600 m (2000 ft) is composed of red, green, and gray sandstones, graywackes, and arkoses that vary from fine to very coarse grained and grade to conglomerate. Some red and green beds of fine grained sandstone and shale are found at the upper portion of the formation in the Muralla valley. Burckhardt[4] established the age of this formation as late Neocomian and early Aptian (based on studies made by C. J. Hares, L. B. Kellum, E. Boese, and O. A. Cavins).

Metalliferous Deposits in Several Mines: The following districts are shown on the accompanying map.

Reforma District: The most important active mine of the region, the Ocampo Unit of Cia. Minera de Penoles in Reforma, has produced more than 1 million tons of ore consisting of oxidized lead minerals, mostly cerussite, bearing small amounts of silver. Gangue is calcite, quartz, iron oxides, and barite.

The deposit lies on the western flank of the asymmetrical and slightly overturned anticline of Sierra

STRATIGRAPHIC COLUMN IN SIERRA DE LOS MUERTOS
NEAR MONTERREY, N.L. MEXICO
AFTER W.E. HUMPHREY

	TEXAS	EUROPEAN STAGES		SIERRA DE LOS MUERTOS		THICKNESS IN MTS
UPPER CRETACEOUS	AUSTIN	SANTONIAN		PARRAS SHALE		1400±
		CONIACIAN				
	EAGLE FORD	TURONIAN		INDIDURA FORMATION		550±
	WOODBINE	CENOMANIAN				
	WASHITA			CUESTA DEL CURA FORMATION		120 TO 150
LOWER CRETACEOUS	FREDERICKSBURG	ALBIAN	UPPER GAULT			
			LOWER GAULT	AURORA LIMESTONE		300 TO 450
	TRINITY		LOWER ALBIAN			
		APTIAN	GARGASIAN	LA PEÑA FORMATION		8 TO 40
			BEDOULIAN	CUPIDO FORMATION		600 TO 750
		NEOCOMIAN	BARREMIAN			
			HAUTERIVIAN	TARAISES FORMATION		260±
			VALANGINIAN			
			BERRIASIAN			
UPPER JURASSIC		TITHONIAN		LA CASITA FORMATION		
		PORTLANDIAN			UPPER MEMBER	370±
		KIMMERIDGIAN			LOWER MEMBER	300
		OXFORDIAN	ARGOVIAN	ZULOAGA LIMESTONE		90±

Fig. 2—Refer to text for brief summary of these formations.

de la Purisima, replacing dolomitic limestone beds near the base of the Cupido formation.

Commercial mineralization occurs for 1700 m (5600 ft) along the strike, and slightly more than 400 m (1300 ft) down the dip. The strata are practically vertical in the lower levels of the mine, but the upper levels are located near the top of the arch, where the beds are flattening. Secondary flexures have an important role in the structural control of individual ore shoots.

Mineralization is not confined to a particular bed, but localization of ore within the stratigraphic column varies through the mine between 8 and 60 m above the top of the Patula Arkose. The ore-replaced unit lies at an average of 150 m (500 ft) below the base of La Pena formation.

San Rafael Mine: This mine lies in a small range formed by an anticline parallel to the regional trend. A small synclinal flexure is superposed on the crest of the major fold, and a fault is located close to the axial plane of the anticline. Vertical displacement along the fault is more than 300 m (above 1000 ft).

The Indidura, Aurora, La Pena, and Cupido formations are present in San Rafael. La Pena beds are about 30 m (100 ft) thick, and the Cupido formation comprises a limestone unit 40 m (130 ft) thick resting over 150 m (500 ft) of black, sugary dolomitic limestone. This section is underlain by a unit that includes shaly limestone, shale (generally carbonaceous), sandstone, and conglomerate that marks the transition to the Patula Arkose.

Sphalerite, galena, subordinate pyrite, and small amounts of gangue are found in San Rafael replacing some members of the transition unit, 10 to 30 m (about 30 to 100 ft) below the base of the black dolomitic limestone of the Cupido formation.

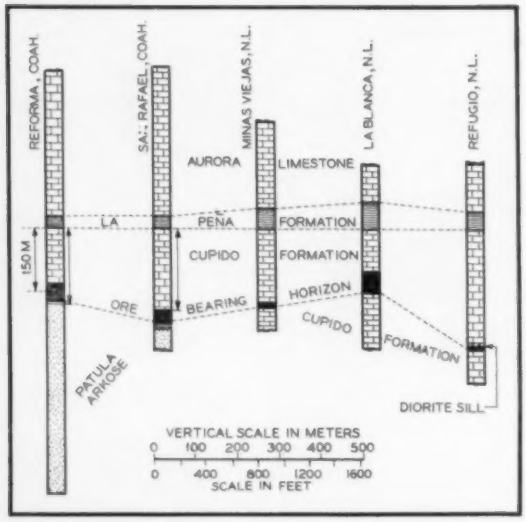

Fig. 3—Stratigraphic sections corresponding to several mines in northeastern Mexico.

Mineralizing solutions ascended along the axial fault until they reached the favorable horizon where the replacement took place, forming a pipe-like orebody. Part of the solutions leaked beyond the horizon and deposited their mineral load in small tabular bodies along the fault.

Minas Viejas: This district is located near the summit of the Iguana range, which is formed by a nearly symmetrical anticlinorium. Several monoclinal folds, minor canoe synclines, and other flexures occur in the upper part of the major structure.

These minor folds had a predominant role in the structural control of the ore deposits, and some of the largest orebodies have been found in gently dipping beds, in the vicinity of those places where the dip of the strata changes abruptly.

The mineral deposits occur as lead and zinc *mantos* replacing certain horizons of the Cupido formation. The ore is found in an advanced state of oxidation, but relict galena is not uncommon. The bulk of the production has consisted of argentiferous lead ore, while zinc has been produced in subordinate amounts.

The major ore horizon is located about 180 m (600 ft) below the base of La Pena formation, or 40 m (130 ft) below the local unit named *La Calle,* which is a very conspicuous unit and an excellent local marker. Eight dolomitic beds have been recognized under *La Calle,* and ore is often found in an 8 m (25 ft) thick horizon that includes three dolomitic beds.

La Soledad: This mine lies at the foothill of the Iguana range, in the eastern limb of the Minas Viejas fold. The Soledad deposit is similar to that of Minas Viejas, and ore occurs in about the same stratigraphic position.

La Blanca: La Blanca district is located in the northeastern limb of a very gentle anticline. The mineral deposit occurs as a practically horizontal pipe-like body of thoroughly oxidized argentiferous lead minerals, low grade zinc ore, and large amounts of iron oxides. It has been mined out over a length of 2 km (1.25 miles).

The ore horizon is part of the Cupido formation and lies within 100 to 150 m (350 to 500 ft) below the base of La Pena formation. Several thin dolomitic beds are found in the vicinity of the replaced beds, but they have no apparent effect on the orebody.

In the outskirts of La Blanca mine there are several narrow veins along which mineralizing solutions reached the impervious La Pena shaly beds and formed thin *mantos* of little importance.

Refugio—El Oso: Five diorite sills, 2 to 40 m (7 to 130 ft) thick, intrude the gently dipping Cupido strata in this area. The ore deposits are pipe-like bodies of lead, zinc, and silver sulfides replacing limestone just underneath some of the sills. Structurally, the orebodies are controlled by steep fractures, which formed channelways for mineralizing solutions, and by the damming effect of the igneous sills.

The largest body of Refugio occurs 280 m (900 ft) below La Pena formation, while the corresponding distance at El Oso is 235 m (770 ft). This last orebody is very small in cross section, but it is continuous over 1 km along the strike. The minerals of El Oso are oxidized.

Factors Responsible For Location of Favorable Horizons: Fig. 3 shows the position of the ore-bearing horizons in the stratigraphic columns of the mines that have been described. The uniformity of the position of the replacement *mantos* in all the mines is evident, except in El Refugio, where the presence of igneous sills introduced a modification that readily explains the variation.

A question arises as to the reason for such uniformity over a very large region, and why the deposits were formed in the Cupido beds in preference to other strata, such as the similar Aurora limestone.

Prescott,[5] who studied the limestone replacement deposits of central-northern Mexico, affirms that about 50 pct of all the tonnage mined out in that province was derived from a single horizon. His explanation is that "the only discernible common factor in all cases is the position of the bed at or near the base of limestones." Nevertheless, Fig. 3 shows that in the case of northeastern Mexico there is a remarkable uniformity in the location of the ore *mantos,* in spite of a marked difference in the type of the immediate underlying sediments.

Two factors are fundamentally responsible for the stratigraphic position of the mineralized bodies, i.e., depth of the formation during the metallogenic epoch, and the characteristics of the favorable beds.

The region under study remained under the sea until the Eocene,[6] when the orogenic movements started. Igneous stocks were emplaced as a result of the diastrophic deformation that continued until late in the Tertiary, and in conjunction with it. The mineralization is supposed to have been related to the igneous activity.

The period of time that elapsed between the orogenic uprising and the mineralizing activity was relatively short. It is probable, therefore, that the thickness of Upper Cretaceous and Tertiary sediments may have been more or less uniform throughout the region. Consequently, the pressure of the mineralizing solutions that were ascending through various channels in the region, in the same epoch, must have been approximately uniform at a given horizon. The sealing effect of the widespread La Pena shaly beds no doubt further increased the uniformity in the pressure of the ascending mineralizing solutions.

It is the writer's opinion that the mineralizing solutions traveled from a deep-seated source until the proper conditions of temperature and pressure for ore deposition were found and that the Cupido formation was buried at the time within the limits of that favorable vertical range. Localization of the orebodies in a particular horizon, within the Cupido formation, was due to characteristics that must be peculiar to certain beds.

Hayward and Triplett[7] have shown that dolomitic limestones play important roles in the control of many replacement deposits of northern Mexico. Their illustrations show that dolomites are favorable host rocks in some deposits and that they act as the controlling element in other cases, without any indication of preferential replacement. Fletcher[8] also states that although magnesian content is not an essential characteristic of a favorable horizon, it is "the most important index we have for favorable horizons."

The dolomitic limestones of the Cupido series are believed to be the final instrument responsible for the stratigraphic position of the orebodies. The mineral deposits are not confined to dolomitic beds in the mines described, but they undoubtedly were a controlling factor in the circulation of mineralizing solutions, offering better circulating media, in some instances, and in other cases acting as barriers to solutions.

Acknowledgments

The stratigraphic columns of the various mines described have been measured in the field by the author, who is solely responsible for the data and ideas expressed. Nevertheless, all the basic information has been obtained on behalf of Cia. Minera de Penoles, S. A., and much valuable knowledge has been derived from the study of its files.

Thanks are given to F. L. Wingfield, chief geologist, and to other officials of Cia. Minera de Penoles, for their permission to publish this article.

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Flotation of a Canadian Kyanite

by R. A. Wyman

Laboratory and pilot plant investigations yield successful results.

KYANITE schists in the Sudbury area have been generally described by Haw,[1] who has also given particular information on preliminary treatment of three large samples from Dryden township, Ontario.[2] Kyanite, garnet, biotite, quartz, and feldspar comprise the main ingredients of this ore. Kyanite is the valuable mineral.

About 5½ tons of −35 +200 mesh product, made by dry rod milling, screening, and separation on the Exolon magnetic separator, were available for treatment by flotation. Magnetic separation had effectively reduced garnet and biotite so that flotation feed consisted essentially of kyanite, quartz, and feldspar, the kyanite content averaging 32 pct and representing about 86 pct of the kyanite in the original ore.

Earlier work on kyanite at the Mines Branch, Ottawa, [3-5] employed an acid circuit, but to avoid production difficulties in the use of acids and at the same time take advantage of the fact that industrial minerals respond somewhat to soap flotation, it was decided first to investigate the higher pH levels.

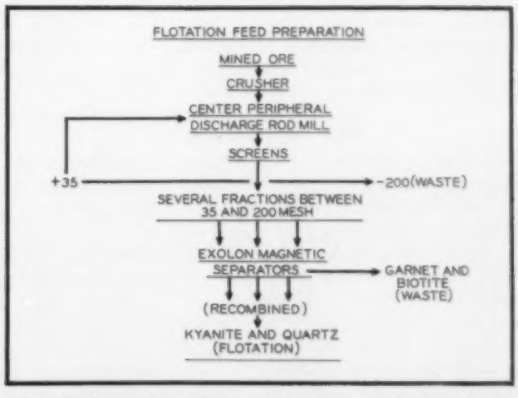

Fig. 1—Stages in preliminary treatment of flotation feed prior to pilot plant operation.

Exploratory tests using −65 +200 mesh feed ended with production of 96.6 pct kyanite concentrate rep-

R. A. WYMAN, Member AIME, is Head of the Milling Section, Department of Mines and Technical Surveys, Industrial Minerals Div., Ottawa.

TP 4510. Manuscript, Feb. 16, 1956. New York Meeting, February 1956.

resenting an 80 pct recovery. This was derived from a system employing warm distilled water, sodium silicate (for quartz depression), sodium carbonate, and oleic acid. Used to cover the coarser size feed of −35 +200 mesh, the same system recovered 76 pct at 94 pct grade. Additional laboratory testing sought to establish optimum conditions for pilot plant work.

Conditioning: Oleic acid conditioning times from 2 to 8 min were tried, but 4 min proved adequate provided pulps were kept above 30°C.

No advantage was gained through adding the oleic acid in steps, and no improvement was observed when the collector was added to cleaning stages.

Density: Up to about 20 pct solids, recovery was found to increase as density increased. At 25 pct solids, adopted for most of the tests, recoveries and grades were generally satisfactory.

Concentrations of Reagents, pH: Several tests were done with progressively smaller reagent concentrations. As reagent level dropped, less cleaning was required. Table I shows recovery and grade in relation to reagent input and number of cleaners. Density of flotation was 25.2 pct solids for each test. The most interesting result appears in D, with low sodium carbonate and sodium silicate input (1.0 and 0.2 lb per ton respectively), and with oleic acid at 2.0 lb per ton.

Table I. Recovery and Grade in Relation to Reagent Input and Number of Cleaners

	Reagents, Lb per Ton				Recovery, Pct	Grade, Pct	pH
	Na_2SiO_3	Na_2CO_3	Oleic Acid	Cleaning Stages			
A	0.8	5	2	6	78.3	97.0	10.0
B	0.4	5	2	5	72.5	97.1	10.1
C	0.2	3	2	4	78.1	96.4	9.8
D	0.2	1	2	4	87.4	95.0	9.2
E	0.2	1	1.5	3	76.6	96.5	9.2

Water Source: Early in the laboratory testing it was noted that about three times as much collector was required when tap water was used as when distilled water was used. An effort was therefore made to determine whether some form of water treatment should be employed. With the lower collector input, distilled or demineralized water gave better results than water softened with sodium ion exchange resin.

Number of Cleaning Stages: The general testing suggested that two or perhaps three cleaning stages would be sufficient.

Pilot Plant Operations

Stages of preliminary treatment of flotation feed are presented in Fig.1. The flotation pilot plant designed and assembled on the basis of laboratory study is illustrated in Fig. 2.

Froth characteristics noted in the laboratory work were sought in the pilot plant operation. Best results with fewest cleaning stages are produced with a fine, white, effervescent and apparently lightly mineralized froth on the roughers and a thick, matted, heavily mineralized froth in the cleaners. In the laboratory, appearance of rougher-type froth on the cleaners meant extra cleaning stages, and in the pilot plant insufficiently cleaned concentrate. Sodium carbonate passing into the cleaners with rougher froth was found to account for carry-over of froth type. In the laboratory, reducing sodium carbonate input had cleared the matter up. In the pilot plant, reducing the sodium carbonate input from 1.0 to 0.7 lb

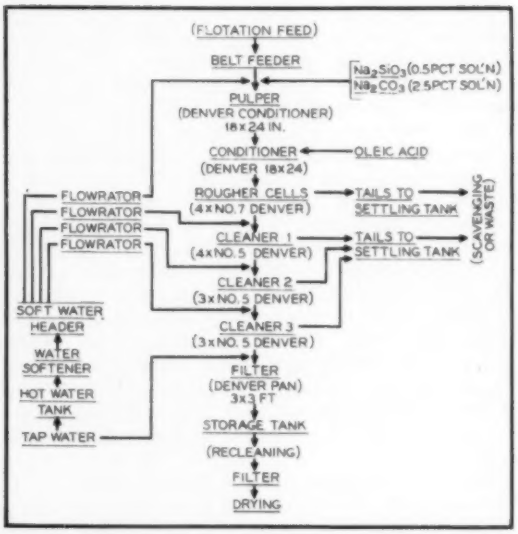

Fig. 2—Flotation circuit of pilot plant designed and assembled on the basis of laboratory study.

per ton (some sodium was picked up from water softeners) improved the froth characteristics but did not solve the cleaning problem as neatly as reduction of this reagent had in the laboratory.

Densities had been planned as 25 pct solids in roughers and 10 pct solids in cleaners, but these were modified to about 20 pct solids in all stages, and this level was continued throughout.

Grade was found to increase from 70 to 98 pct kyanite as collector input decreased from 2.5 lb per ton to 0.65 lb per ton. Correspondingly, recovery decreased from 86 to 65 pct. Under conditions approximating those used in the laboratory, recovery averaged 80 pct and grade 76 pct, with tails of 10 pct. Products were retreated in various ways to produce satisfactory overall results. For example, scavenging the tails and recleaning the concentrates produced a product grading 95 pct kyanite for a recovery of 85 pct. Tabling the tails and recleaning the concentrates gave a grade of 94 pct kyanite for a recovery of 85 pct. These figures are based on flotation feed, which itself represented 86 pct of the kyanite in ore. Indicated recovery by this system is, therefore, about 73 pct.

Acknowledgment

The author gratefully acknowledges the close cooperation of V. A. Haw throughout this investigation, particularly in providing prompt and efficient minerals separation analyses.

References

[1] V. A. Haw: Kyanite in Canada. CIM *Bulletin*, January 1954, vol. 47, p. 27. Mines Branch, Department of Mines and Technical Surveys, Ottawa, Canada.

[2] V. A. Haw: Progress Report—Investigation of Methods for Recovery of Kyanite from Samples Submitted by the Hoyle Mining Company, Limited, Sudbury, Ontario. *Industrial Minerals Report No. 295*, November 1954. Mines Branch, Department of Mines and Technical Surveys, Ottawa, Canada.

[3] H. L. Beer: Concentration of Kyanite Ore from the Hoyle Mining Company, Sudbury, Ontario. *IMR No. 161*, February 1953. Mines Branch, Department of Mines and Technical Surveys, Ottawa, Canada.

[4] H. L. Beer: Batch Concentration Tests on Kyanite Ore from Kyanite Corporation of Canada, Mattawa, Ontario. *IMR No. 163*, March 1953.

[5] H. L. Beer: Flotation Concentration of a Sample of Kyanite Ore from the Property of Strategic Metals Limited, Clarendon, Ontario. *IMD No. 206*, October 1953.

Discussion of this paper sent (2 copies) to AIME before Feb. 28, 1958, will be published in MINING ENGINEERING.

AIME OFFICERS:

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News of . . .
Society
Institute
Profession

Pacific Southwest Minerals Conference To Be Held in March

Sponsored by the AIME San Francisco Section, the 1958 Pacific Southwest Minerals Industry Conference will be held at the Hotel St. Francis in San Francisco on March 27 to 29.

Fred Lohse, general chairman, reports that the first regional conference, held in Reno last April, established a standard of excellence that will be a challenge to surpass. The committee this year expects to put the emphasis during the meeting on youth with the hope that many of the junior men in the mineral industries in the region will be given an opportunity to attend, along with their wives. Plans now include presentation by men in the 35 to 45 age bracket of most of the papers at the meeting.

Included on the program will probably be papers by the younger men in the chemical and process industries in the Southwest region. The aim in scheduling such papers is to give industrial minerals producers a better insight into the pro-

(Continued on page 118)

Available SME Preprints

For SME Abstracts and SME 1958 Annual Meeting Program, see pages 40 and 58, respectively.

5817A1	5818A17
5817A2	5819A1
5817A3	5819A4
5817A5	5819A7
5817A10	5819A8
5817A11	5819A9
5817A12	5819A10
5817A13	5819A11
5817A20	5819A12
5817A23	5819A13
5817P1	5819A15
5817P3a	5819P4
5817P3b	5819P5
5817P3c	5819P6
5817P3d	5819P7
5817P10	5819P12
5817P14	5820A2
5817P17	5820A4
5817P18	5820A6
5817P20	5820A8
5817P24	5820A15
5818A1	5820A16
5818A1a	5820A17
5818A1d	5820A19
5818A2a	5820P1
5818A3	5820P3
5818A5	5820P4
5818A13	5820P9
5818A15	5820P10
5818A16	5820P16
5820P19	

SOCIAL FUNCTIONS
SOCIETY OF MINING ENGINEERS OF AIME
1958 ANNUAL MEETING

Monday, February 17

12:00 noon	Welcoming Luncheon	Statler Hotel
6:00 pm	Pre-Smoker Cocktail Party	Statler Hotel
8:00 pm	Dinner-Smoker, Stag dinner and entertainment	Statler Hotel

Tuesday, February 18

7:30 am	MBD Scotch Breakfast	Statler Hotel
6:00 pm	SME Cocktail Party	Statler Hotel
7:00 pm	SME Annual Dinner	Statler Hotel
9:00 pm	AIME Informal Dance	Statler Hotel

Wednesday, February 19

7:00 pm	Annual AIME Banquet and President's Reception	Waldorf-Astoria Hotel

Annual Mining Meeting In Duluth in January

The 19th Annual Mining Symposium, sponsored by the University of Minnesota through its Center for Continuation Study, will be held at the Norshore Theater in Duluth on January 14 and 15. As in previous years, the Symposium will be held in conjunction with the annual meeting of the AIME Minnesota Section.

Subjects to be covered on the program include: handling of intermediate ores, particularly scrubbing and screening, which will be discussed by two panels; design and operation of surge pits and surge bins; stockpiles and handling of concentrates; design and preparation on tailings ponds; and open pit operational subjects.

Concerned with arrangements for the Symposium are William R. Derrick, Derrick Mfg. Co.; R. C. Engstrom, Mine & Smelter Supply Co.; Stephen E. Erickson, The M. A. Hanna Co.; R. C. Ferguson, Hardinge Co. Inc.; R. L. Fye, McLanahan and Stone Corp.; George Glumac, The M. A. Hanna Co.; Don Kimball, Pacific Isle Mining Co.; Chelsea R. Phillips, Hewitt-Robins Inc.; James Stukel, Cleveland-Cliffs Iron Co.; and W. R. VanSlyke, Cleveland-Cliffs Iron Co.

New Appointments For SME Staff Members

At the Nov. 18, 1957, AIME Board of Directors meeting, two changes involving members of the SME staff were announced. John Cameron Fox, who became SME Secretary on July 1, has received the additional appointment as Assistant Secretary of the Institute. Donald R. Tone, formerly associate editor of MINING ENGINEERING, has been appointed Assistant Secretary of SME, effective January 1. Mr. Fox's appointment was effective November 18.

INDUSTRIAL MINERALS DIVISION

NEWSLETTER

Dear Members of the
Industrial Minerals Division:

The right to vote implies that you have something at stake. In this case, your stake has not been changed in fundamentals, but the recent AIME reorganization made it necessary that our Bylaws be revised in accord with the language and requirements of the new Bylaws of the Society of Mining Engineers of AIME.

In this revision, your committee has taken advantage of the opportunity to clarify other aspects of the Bylaws. Principal changes are in *Articles III, V, and VI.* This revision has been approved by our full Executive Committee, and is presented below for your study and vote. Please send your ballot (**below**) promptly to John G. Broughton, our Secretary-Treasurer, who managed the revision as chairman of the Bylaws Committee.

This is only one of many changes necessary in this first year of the AIME reorganization, and it is also one of the most important. We should not begin a new year without the new Bylaws in effect, and hence they should be presented for the approval of the AIME Board in February. The approval of our members and of the SME Board is being requested before that time.

Besides handling essential Divisional business during 1957, your officers and other members have participated in the streamlined operation of SME, have substantially advanced such special projects as the new edition of *Industrial Minerals and Rocks* and the proposed Industrial Minerals Award, and have actively entered into the problem of nominating the President-Elect of AIME for 1959. The assistance given by our people in such successful technical programs as those at Reno, Portland, Salt Lake City, and Tampa was strongly rewarded by large attendances and keen interest—and small wonder, in view of the wide commodity field that we cover, and the accelerated entry of technical men. In short, a climate has developed in which large membership growth can take place.

T. L. Kessler

Article I

Name and Objectives

Section 1. This Division shall be known as the Industrial Minerals Division of the Society of Mining Engineers of the American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc. The official abbreviation of the Division's name shall be IndMD.

Section 2. The objectives shall be to promote the arts and sciences connected with the economic production and utilization of industrial minerals (nonmetallics) and the professional standing of those employed in those industries, to hold meetings which provide for both the gathering of the profession and the reading and discussion of professional papers, and to circulate by means of publications the information thus obtained.

Article II

Members

Section 1. Any member of the AIME in good standing may become a member of this Division by written notification to the Secretary of the Institute.

Article III

Dues and Assessments

Section 1. Dues or assessments may be fixed by the Executive Committee of the Division, subject to the approval of the Board of Directors of the Society of Mining Engineers of AIME.

Industrial Minerals Division Members _____

VOTE NOW

Please signify your approval or disapproval of the proposed Bylaws by marking *X* is the proper box below. **Sign and return this ballot** (before midnight, January 31) to: *John G. Broughton, IndMD Secretary, State Education Building, Room 448, Albany 1, N. Y.*

I approve the Proposed Bylaws as published in the January 1958 issue of MINING ENGINEERING

☐ YES ☐ NO **Signed:**.....

NOTE: This is the letter ballot required by the Bylaws. Ballots will be invalid unless marked, signed, and postmarked no later than midnight, Jan. 31, 1958.

Article IV

Meetings

Section 1. The Annual Meeting of the Division shall be held as a part of the Annual Meeting of the AIME. Meetings may be held at such other times and places as may be determined by the Executive Committee subject to the approval of the Board of Directors of the Society of Mining Engineers of AIME.

Section 2. The annual business meeting shall be held during the Annual Meeting of the AIME, at which the new officers shall be installed as provided in **Article VII**, *Section 2*, and such other business transacted as may properly come before the meeting.

Section 3. A Divisional business meeting, other than that provided for in *Section 2*, may be convened by order of the Executive Committee at any meeting of the Division for which notice has been sent to the members of the Division through the regular mail or in MINING ENGINEERING at least thirty (30) days in advance and any business be transacted not inconsistent with these Bylaws or with the Bylaws of the Society of Mining Engineers.

Section 4. For the transaction of Divisional business at any meeting requiring the vote of the membership, the presence of a quorum of not less than 25 members of the Division shall be necessary.

Article V

Officers and Government

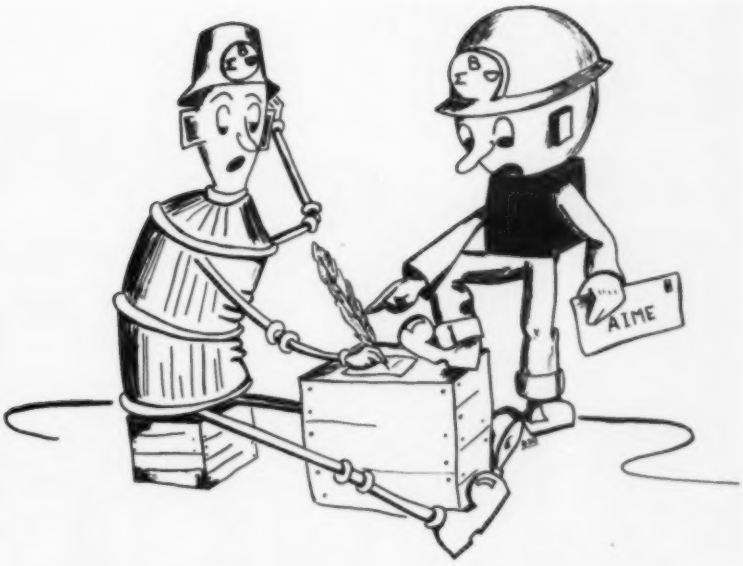
Section 1. The Officers of the Division shall consist of a Chairman, at least four Vice Chairmen (the Eastern Vice Chairman shall be the Senior Vice Chairman), and a Secretary-Treasurer. The Vice Chairmen shall be chosen to represent at least four geographical areas in North America. (Currently the Division has designated, instead of a Western area, a Northwest and a Southwest area.)

Section 2. The government of the affairs of the Division shall rest in an Executive Committee, insofar as is consistent with the Bylaws of the Division, the Society of Mining Engineers, and the Constitution and Bylaws of the AIME.

Section 3. The Executive Committee shall consist of the Past Chairman, the Chairman, the Vice Chairmen, Secretary-Treasurer, ex-officiis, and nine members, all of whom (except the Past Chairman) shall be nominated and elected as provided hereafter in **Article VII**.

Section 4. The Chairman and Vice Chairmen of the Division shall serve one year each, or until their successors are elected. In case of resignation, death, or disability of the Chairman, he shall be succeeded by the Senior Vice Chairman. The nine elected members of the Executive

(Continued on page 118)



Embie, Jr., says, "If you are an MBD member or if you wish to associate with our Division and you do not now receive the MBD newsletter, then you may correct our mailing list only by writing to *John C. Fox, Secretary, Society of Mining Engineers of AIME, 29 W. 39th St., New York 18, N. Y.* The MBD uses the facilities of the AIME for addressing its Newsletters and, therefore, only those members who have indicated MBD interest on AIME questionnaires will receive our best seller."

Proposed Bylaws

Minerals Beneficiation Division

Article I

Name and Object

Section 1. This Division shall be known as the Minerals Beneficiation Division of the Society of Mining Engineers of the American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc. The official abbreviation of the Division's name shall be MBD. The Society of Mining Engineers is hereinafter referred to as the Society.

Section 2. The objective of the Minerals Beneficiation Division shall be to furnish a medium of cooperation among those interested in the basic unit processes and unit operations of minerals beneficiation; and to promote the advancement of this branch of mineral technology through meetings for professional and social intercourse, and to stimulate the preparation, reading, discussion, and circulation of papers connected therewith.

Article II

Members

Section 1. Any member of the AIME of any class and in good standing may become a member of this Division by indicating his choice on the membership application form, or by letter to the Secretary of the AIME, that he desires to be classified as a member of the Division and to receive publications of the Division.

Article III

Finances

Section 1. There shall be no dues for this Division but voluntary contributions may be solicited, subject letter to the Secretary of the AIME,

Section 2. The disbursement of funds received by the Minerals Beneficiation Division shall be authorized by the Executive Committee of the Minerals Beneficiation Division.

Article IV

Meetings

Section 1. The Minerals Beneficiation Division shall meet as a regular and integral part of the Annual Meeting of the Society, and at such other times and places as may be determined by the General Committee of the Minerals Beneficiation Division.

Section 2. The Annual Meeting of the General Committee of the Minerals Beneficiation Division shall be held during the Annual Meeting of the Society.

Section 3. A business meeting of the Minerals Beneficiation Division may be convened by order of the Execu-

(Continued on page 119)

Bylaws

Don't forget to vote; mark, sign, and mail the ballot now.

Minerals Beneficiation Division Members

VOTE NOW

Please signify your approval or disapproval of the proposed Bylaws by marking an *X* in the proper box below. **Sign and return this ballot** (before midnight, January 31) to: *H. Rush Spedden, MBD Secretary-Treasurer, Union Carbide Ore Co., 30 E. 42nd St., New York 17, N. Y.*

I approve the Proposed Bylaws as published in the January 1958 issue of MINING ENGINEERING

☐ YES ☐ NO **Signed:**_____

NOTE: Ballots will be invalid unless marked, signed, and postmarked no later than midnight, Jan. 31, 1958.

Head table guests at the welcoming luncheon included, left to right: Roy O'Brien, F. L. Smith, A. L. Hill, C. L. Barker, Truman Kuhn, R. L. Scott, J. D. Forrester, J. W. Vanderwilt, Governor McNichols of Colorado, Grover J. Holt, S. D. Michaelson, A. H. Patten, W. H. Miles, Jr., Mrs. J. P. Harrison, L. J. Parkinson, G. M. Wilfley, and J. C. Fox. Mr. Holt, AIME President, was the principal speaker at the luncheon.

A WELL attended uranium panel discussion, excellent technical sessions, outstanding social events, outline of AIME development, and a windup "field trip" highlighted the fourth annual Rocky Mountain Minerals Conference, attended by around 400, in Denver, October 30 through November 1.

AIME President Grover J. Holt started the proceedings at the welcoming luncheon with a talk on the initiation and development of the Long Range Plan of AIME. Put into operation at the New Orleans Annual Meeting in February last year, the Plan called for rewritten By-laws, under which authority was decentralized and delegated to a greater degree than before. Basically the Plan called for setting up within the Institute three separate and individual Societies, the Society of Mining Engineers, The Metallurgical Society, and the Society of Petroleum Engineers. Mr. Holt gave the Conference delegates a description of how the plan is working, with special reference to the "grass roots" or Local Section level; the background of need for such a Plan; and some idea of how it may develop.

A word of greeting was conveyed by Governor McNichols of Colorado on behalf of his state and other western governors. He touched briefly on some topics of keen interest to mining and metals engineers—tariffs, prospecting programs, atomic energy, education, Colorado mineral policy.

In place of field trips, the Conference committee arranged an expedition to the Colorado University vs Missouri football game at the University stadium, above, in Boulder. On the way there was a stop in Golden to give "field trippers" an opportunity to tour the Coors Brewery. Box lunches were provided for the journey which left Denver at 9:45 am.

Mining Sessions

For the technical session which followed the Wednesday luncheon, topics of particular interest to miners were scheduled: *Milling Practice on the Mesabi Range* by E. C. Herkenhoff, *Shaft Sinking at Homestake Mine* by W. C. Campbell, *Sampling at Rio de Oro* by J. Q. St. Clair, and *Ground Water in Colorado* by T. G. McLaughlin.

On Thursday morning the following topics were discussed: *Development in the Metallurgy of Columbium and Tantalum* by Sherman May, *Tunneling* by T. F. Adams,

Fourth Annual Rocky Mountain Minerals Conference Attended By Over 400; Colorado Section Host

Recent Developments, Exploration Activities of the Cerro de Pasco Corp. by F. N. Spencer, Jr., and *Magma's Limestone Replacement Ore Body* by R. N. Webster.

The Metallurgy of Mixed Oxidized Copper Ore of the Pima Mining Co. by G. A. Komadina, *Hydraulic Backfilling* by R. M. Stewart, *A Survey of Electromagnetic Prospecting Methods* by G. R. Rogers, and *Status of Copper Mining in Arizona* by H. A. Schmitt were scheduled for Thursday afternoon.

Uranium Panels

Friday was generally uranium day with two panels scheduled in the afternoon. At the morning technical session, the following topics were covered: *Milling Practices at the American Chrome Co.* by W. H. Hisle, *Recent Trends in Mining Machinery Development* by C. O. Frush, and *Trends in Uranium Geology* by E. E. Thurlow.

The afternoon was devoted to two panels on uranium, one for miners and geologists and the other for metallurgists. The mining and geology panel was under the direction of Col. W. W. Fertig and participating were J. W. Hill, G. T. Bator, D. T. Delicate, D. C. Anderson, R. A. Ashby, C. C. Towle, H. R. Wardwell, J. F. Whalen, R. G. Sullivan, M. F. Ayler, D. F. Coolbaugh, and R. J. Wright. As a basis for discussion, the following subjects were posed: recovery of cores from relatively unconsolidated deposits, interpretation of radiometric logs, the mining of thick wet horizontal lenticular orebodies having an incompetent back, calculation of uranium ore reserves from drill hole information, and correlation of mining extraction with ore estimates obtained by interpretation of drilling data.

The metallurgy panel discussed three topics: performance of solvent extraction recovery systems, selection of liquid-solid separation systems in uranium metallurgy, and operating problems with ion exchange recovery processes. Panelists, under the direction of H. L. Hazen, chairman, were: R. C. Toerper, M. F. McCarty, C. J. Lewis, W. C. Hazen, Jack Melin, E. S. Allen, C. E. Osborn, J. W. Barnes, A. H. Ross, Gene Meyer, C. K. McArthur, Wm. Joyce, and R. S. Porter.

Social Events

In addition to the welcoming and president's luncheon on Wednesday, there were other social events during the three-day meeting. Mining companies and suppliers held a cocktail party at the University Club on Wednesday evening. A western-style breakfast started off Thursday's events, and an informal dinner-dance closed the meeting on Friday evening On Saturday an interesting "field trip," described on the opposite page, was held.

Ladies' Program

For the ladies, there were numerous opportunities to get together during the coffee hours held each morning. On Thursday the ladies attending traveled to the Columbine Country Club for luncheon and a talk on books. They, of course, were welcomed at all social functions.

Conference Committee

Plans and preparations for the Conference were under the direction of E. H. Crabtree, general chairman, and his assistant, R. L. Scott. Their committee chairmen were: Mrs. J. P. Harrison, WAAIME events; L. J. Parkinson, programs; C. L. Barker, arrangements; G. M. Wilfley, entertainment; A. L. Hill, budget; and F. L. Smith, secretary.

Members of the various committees were: *WAAIME*—Mrs. R. L. Scott, Mrs. C. L. Barker, Mrs. A. L. Hill, Mrs. W. E. Jones, Mrs. J. J. Curzon, and Mrs. W. L. Miles, Jr.; *program*—F. T. Davis, W. E. Heinrichs, Jr., J. Q. St. Clair, and D. O. Rausch; *arrangements*—W. L. Crow, E. D. Dickerman, E. J. Garbella, H. W. C. Prommel, C. V. Johnson, W. L. Miles, Jr., R. W. Graeber, R. H. Shaw, R. B. Olson, S. D. Coyle, A. J. Davison, R. L. Druva, J. L. Monarchi, D. W. Johnson, and H. L. Meunch; *entertainment*—W. T. Ahlborg, J. W. Goth, R. L. Stark, and D. J. Drinkwater; and *budget*—V. R. Martin and W. L. Miles, Jr.

The AIME Colorado Section was host and sponsor for the Conference. Officers of the Section are: A. H. Patten, chairman; T. H. Kuhn, vice chairman; W. L. Miles, Jr., secretary-treasurer; and Mrs. J. P. Harrison, chairman, WAAIME.

Among the major social events during the three-day meeting was the informal dinner-dance at the Silver Glade of the Cosmopolitan Hotel. Snapped during a pause in the proceedings were the Conference general chairman, E. H. Crabtree, and the assistant general chairman, R. L. Scott.

IndMD Bylaws

(Continued from page 114)

Committee shall serve for three years.

Section 5. With the exception of the Secretary-Treasurer, no officer or member of the Executive Committee may be immediately re-elected to the same office.

Section 6. For the transaction of business at meetings of the Executive Committee, the presence of a quorum of not less than five members shall be necessary, together with sufficient proxies to give a total of at least eight, including those present and proxies. In the event a member cannot attend, he may deliver his proxy to any member of the Division he wishes to designate, or to the Chairman or the Secretary-Treasurer to bestow as they may best decide.

Section 7. In accordance with **Article V** of the Bylaws of the Society of Mining Engineers of AIME, a member of the Division who shall also be an ex-officio member of the Executive Committee, shall be appointed each year to serve for three years as a representative of the Industrial Minerals Division on the Board of Directors of the Society.

Article VI

Committees

Section 1. There shall be the following standing Committees: Nominating, Membership, Program, and such technical committees as may be authorized by the Executive Committee. In addition, there shall be a Divisional Publications Committee, auxiliary to the Editorial Board of the Society of Mining Engineers of AIME, personnel of which shall be appointed by the President of the Society as recommended by the Chairman of the Division. When possible, the Nominating Committee shall be made up of the five most recent Past Divisional Chairmen.

Section 2. The Chairman of the Division shall appoint the Chairmen of all Standing Committees. All committees shall be appointed by December 1 of the calendar year preceding their term of office and the list shall be submitted to the Executive Committee for approval at the Annual Meeting.

Article VII

Nomination and Election of Officers and Appointment of Committees

Section 1. Every year the Division shall elect a Chairman, the Vice Chairmen, a Secretary-Treasurer, and three members of the Executive Committee. In addition, the Division shall nominate each year a member of the Division to serve on the Transactions Editorial Committee and one to serve on the General Editorial Committee of the Society of Mining Engineers (as provided for in **Article VIII** of the Bylaws of the Society).

Section 2. On or before May 15 the Nominating Committee shall report its slate of officers to the Executive Committee, which in turn will report the slate to the Secretary of the Society of Mining Engineers. The full slate of nominees will be published in the *July issue* of MINING ENGINEERING. Other nominations for the offices may be made and endorsed by ten members and forwarded in writing to the Secretary of the Society up to August 15th for publication in the *October issue* of MINING ENGINEERING. If such nominations are made, an election shall be held by letter ballot to be completed by December 31. If no such additional nominations are received, the candidates nominated by the Nominating Committee shall be considered elected and shall take office at the Annual Meeting.

Section 3. It shall be the duty of the Chairman-Elect informally to designate the Chairmen of all committees in sufficient time prior to the Annual Meeting. At this meeting they shall be formally presented to the Executive Committee for approval. The Division Chairman, when making such appointments, shall make clear to his committee chairmen the objectives of the committee's activities during the coming year. Every effort shall be made by committee chairmen to hold a meeting of their committees when the new slate takes office for a new term at the time of the Annual Meeting.

Article VIII

Amendments

Section 1. Proposals to amend these Bylaws shall be made in writing by the Executive Committee or by petition to the Executive Committee signed by at least ten members. They shall be considered by the Executive Committee and announced to the members through the columns of MINING ENGINEERING, together with any comments made by the Executive Committee thereon. They shall be voted upon at a stated meeting of the Division or by letter ballot, as may be directed by the Executive Committee.

4th Nuclear Congress To Be Held By EJC

Over 30 engineering and scientific societies are completing plans for the 4th EJC Nuclear Engineering and Science Conference to be held at the Chicago International Amphitheatre this March.

Developments in atomic energy will be presented from the standpoint of engineers, physicists, metallurgists, and chemists.

The National Industrial Conference Board and the Atomic Industrial Forum Inc. will jointly sponsor an Atomic Energy Management Conference which will be a part of the Congress. This conference is designed to provide management with a comprehensive review of the progress that is being made throughout the world in the development of industrial uses of atomic energy.

The Atomic Industrial Forum Inc., *Atomfair*, will be held in conjunction with the technical sessions of the Congress and will feature the latest developments in industrial uses of atomic energy. Registration for the Atomfair is open to Congress delegates and to science-minded people in industry.

Mr. Landis emphasized that preprints of Congress papers will be available well in advance of the Congress at a nominal cost. These preprints may be ordered from the order form to be included in the advance program for the Congress which will be distributed in January.

Those interested should request copies of this program from the Secretary of the Society to which they belong or from the Secretary of Engineers' Joint Council, 29 W. 39 St., New York 18, N. Y.

Changes Take Place At University of Minnesota

The Minnesota School of Mines and Metallurgy, University of Minnesota, has been reorganized and now comprises three divisions: Mineral Engineering, Metallurgical Engineering, and the Mines Experiment Station. S. R. B. Cooke is head of the School and the three division chiefs are, respectively, E. P. Pfleider (on leave for the spring semester; D. H. Yardley is acting chief), S. R. B. Cooke, and H. H. Wade, appointed director of the Experiment Station.

Physical metallurgy has been transferred to the School of Chemistry where it will function as the Dept. of Metallurgy under M. E. Nicholson.

Separate curricula are now available in metallurgical engineering, geological engineering, mining engineering, and geophysics in the School of Mines and Metallurgy. Metallurgy is available in the School of Chemistry.

Pacific Southwest

(Continued from page 113)

duction problems, especially the specification requirements and the general exploitation of the mineral materials which are supplied to the chemical and process industries.

Program chairman is J. K. Brooke, Kaiser Aluminum & Chemical Corp., Oakland, Calif. Further plans for the Conference will be announced in forthcoming issues of MINING ENGINEERING.

MBD Bylaws

(Continued from page 115)

tive Committee of the General Committee, and business may be transacted not inconsistent with these Bylaws or with the Constitution or Bylaws of the Society and the AIME, provided notice has been sent to the members of the Division through the mail or through notice published in MINING ENGINEERING, and/or the *Newsletter*, at least one month in advance.

Section 4. On petition of 25 or more members of the Minerals Beneficiation Division, the Executive Committee of the General Committee shall call a business meeting of the Division within a reasonable time after receipt of such petition.

Section 5. For the transaction of business at a meeting of the Minerals Beneficiation Division, the presence of a quorum of the General Committee and of not less than 25 members of the Minerals Beneficiation Division in all shall be necessary.

Article V

Government

Section 1. The officers of the Minerals Beneficiation Division shall consist of a Chairman, Associate Chairman, two Regional Vice Chairmen, and a Secretary-Treasurer, to be nominated and elected as provided hereinafter in **Article VIII.**

Section 2. At times other than regular or special meetings of the entire Division the business affairs of the Minerals Beneficiation Division shall be conducted by the General Committee, subject to the Bylaws of the Society and the AIME. The General Committee shall consist of:

- a. Chairman of Division
- b. Associate Chairman of Division
- c. 1st Regional Vice Chairman
- d. 2nd Regional Vice Chairman
- e. Secretary-Treasurer
- f. Papers and Publications Committee Chairman
- g. Last Past-Chairman
- h. All Chairmen of Technical Committees
- i. Membership Committee Chairman
- j. Education Committee Chairman

A quorum of the General Committee shall consist of eight members and a majority vote of those present shall control. In the absence of said quorum at any meeting of the General Committee, a quorum of the Executive Committee, if present, shall transact necessary business, subject to confirmation by letter ballot of the General Committee if the business so transacted is delegated solely to the General Committee by the Bylaws of the Division.

Section 3. The duties of the General Committee of the Minerals Beneficiation Division shall be to decide all questions of policy concerning the Minerals Beneficiation Division provided, however, that in all cases the Bylaws of the Division, the Society, and the AIME shall Govern.

When any officer fails to perform his duties or when any committee fails to perform the duties assigned to it, the General Committee of the Minerals Beneficiation Division shall take such measures as it deems advisable.

Section 4. There shall be an Executive Committee of the General Committee of the Minerals Beneficiation Division consisting of:

- a. Chairman of the Division
- b. Last Past-Chairman of the Division
- c. Associate Chairman of the Division
- d. Secretary-Treasurer
- e. 1st Regional Vice Chairman
- f. 2nd Regional Vice Chairman
- g. Chairman of Papers & Publications Committee.

At meetings of the Executive Committee the presence of four of its members shall constitute a quorum.

This committee is empowered to carry out decisions and policies of the General Committee. The Executive Committee shall also advise and consult with the Chairman of the Division from time to time as required.

Article VI

Officers and Their Duties

The officers shall be nominated and elected as provided hereinafter in **Article VIII.**

Section 1. The Chairman, Associate Chairman, and Regional Vice Chairmen shall serve for one year each, or until their successors are elected and have qualified. The Secretary-Treasurer shall serve for two years, or until a successor has been elected and qualified.

The duties of the Chairman, or of the Associate Chairman during the absence or incapacity of the Chairman, are as follows:

1) Preside at all executive and business meetings of the Minerals Beneficiation Division.

2) Appoint all necessary committees and representatives not provided for in the Bylaws.

3) Preside at opening session of all Minerals Beneficiation Division Meetings.

4) Transact all business of Minerals Beneficiation Division not specifically delegated to other officers by the Bylaws.

5) Represent the Minerals Beneficiation Division in all meetings of the Society and AIME.

6) Preside at the annual Minerals Beneficiation Division luncheon.

7) Take care of all other business of the Minerals Beneficiation Division both in the New York office and elsewhere.

Section 2. The Associate Chairman shall serve as Program Chairman of MBD, and shall select presiding officers for all technical sessions.

Section 3. The Regional Vice Chairmen shall have general duties of promoting the welfare and activity of the Minerals Beneficiation Division in the area assigned to them and carry out duties assigned by the Chairman of the Division.

The 1st Regional Vice Chairman shall serve as Vice Chairman of the Program Committee, accepting duties as assigned by the Program Committee Chairman.

The 2nd Regional Vice Chairman shall serve as MBD representative on the Society General Editorial Committee.

Section 4. The Secretary-Treasurer shall be the Secretary of the General Committee and the Executive Committee and shall perform such duties as assigned to him by the General Committee. He shall also edit and publish the *MBD Newsletter*, under direction of the Division Chairman.

Section 5. The annual term of office for officers of the Minerals Beneficiation Division shall start at the close of the Annual Meeting of the Society and shall terminate at the close of the next Annual Meeting of the Society.

Article VII

Committees

Section 1. In addition to the General Committee and its Executive Committee, as provided in **Article V,** there shall be five Standing Committees as follows:

- a. Nominating Committee
- b. Membership Committee
- c. Program Committee
- d. Papers & Publications Committee
- e. Education Committee

Section 2. There shall be nine Technical Committees as follows:

a. *Material Handling and Storage:* Conveying, Elevating, Pumping; Chutes, Launders, and Flumes; Tailings, Refuse, and Debris Disposal; Bins and Tanks; Ground Storage and Reclaiming; Blending; Feeders; Protective Devices.

b. *Crushing and Grinding:* Crushing; Screening; Grinding; Dust Control; Classification.

c. *Solid Fluid Separation:* Thickening; Filtration, Centrifuging; Drying and Evaporation; Cyclone; Cottrell; Bag House.

d. *Concentration:* Sorting; Washing and Scrubbing; Sizing; Gravity Concentration; Flotation; Electrical Concentration; Magnetic Concentration; Centrifugal Concentration; Amalgamation.

e. *Operating Control:* Weighing; Metering; Sampling; Testing Methods; Automatic Control and Recording Devices; Quality Control;

(Continued on page 121)

AIME Staff, Board of Directors Honor Mrs. Ferry

The AIME Board of Directors took occasion on November 18 to honor Mrs. Grace Townsend Ferry, chief file clerk, upon her retirement from the Institute after 37 years of service. Shown, LEFT, shortly after presentation of a gold watch by the Board of Directors are, left to right, Mrs. Ferry; Roger V. Pierce, Vice President; E. O.Kirkendall, Secretary; and Grover J. Holt, AIME President; RIGHT: Her fellow staff members held a luncheon for Mrs. Ferry on November 26, at which time they gave her a clock and a gold charm to commemorate the date. Standing are P. J. Apol, business manager; Mrs. Ferry; and Mr. Kirkendall.

AIME

BOARD OF DIRECTORS

Recent actions taken by the Institute Board of Directors.

► Staff changes announced at the November 18 AIME Board of Directors meeting: F. Weston Starratt, formerly associate editor, was appointed managing editor, JOURNAL OF METALS; and James J. Burke, formerly assistant editor, was appointed associate editor, JOURNAL OF METALS, both appointments effective Dec. 2, 1957.

► The following members were transferred to senior membership, effective Jan. 1, 1958: E. R. Weidlein, Pittsburgh; Norman E. LaMond, Short Hills, N. J.; W. F. Evans, Chatham, N. J.; Roger L. Strobel, Salt Lake City; Arthur W. Gittins, Pittsburgh; and Daniel R. Hull, Waterbury, Conn.

► Membership Awards are to be continued during 1958. This consists of drawing from the members who have received Membership Awards during the year. The winner is to receive pre-payment of five-years' dues and the four runner-ups, prepayment of one-year's dues

► C. E. Birchenall has been appointed to succeed W. C. Ellis as the AIME representative on the board of directors of *Acta Metallurgica*. Dr. Ellis' term expired December 1957.

► The revised Bylaws of the Coal Division, SME, were approved.

► The revised Bylaws of the Mining, Geology, and Geophysics Division and name change were approved. Effective Feb. 18, 1958, this SME Division shall be known as the Mining and Exploration Division.

► Revised Bylaws of the Institute of Metals Division of The Metallurgical Society were approved with certain changes suggested by Secretary Kirkendall and the Board of Directors of The Metallurgical Society.

► An invitation to AIME to hold the 1967 Annual Meeting in Los Angeles was extended in a letter dated Oct. 8, 1957, by L. D. Jaffe, Chairman, Southern California Section, and D. G. Kingman, Chairman, Southern California Petroleum Section. The Board of Directors have expressed their appreciation of this courtesy and have directed Secretary Kirkendall to accept the invitation with the thanks of the Board.

► The Alfred Noble Prize for 1958 has been awarded to R. D. Bowerman, member of ASME, for his paper *The Design of Axial Flow Pumps*, which was published in ASME Transactions, Vol. 78, p. 1723, November 1956. The award was presented at the ASME Annual Banquet, Dec. 4, 1957, in New York.

► Approval was given for the establishment of the Knoxville Area Subsection of the Southeast Local Section, subject to a revision in the Bylaws to eliminate Article II, Section 2 of the bylaws submitted.

► The following were elected to Honorary Membership in AIME, by unanimous vote: Donald H. McLaughlin, C. H. Mathewson, and Fred Searls, Jr.

► Approval was given for the establishment of the Roswell Petroleum Section, subject to a few minor revisions in the bylaws.

► Approval was given for the establishment of the Snyder Local Section.

► Approval was given for the establishment of the Southwestern Society of Petroleum Engineers Student Chapter at Southwestern Louisiana Institute, Lafayette, La., subject to certain recommended changes in the bylaws.

► The following Citation in honor of J. F. Thompson, recipient of 1958 Rand Gold Medal, was approved:

"For his leadership of a mining and metallurgical enterprise which has contributed to free world strength; for administrative skills which have furthered the progress of the nickel industry; for his vision in stimulating scientific research; for demonstrating the value of a technical education combined with broad interests and human understanding."

Stanford University Starts New Department

Stanford University recently announced the formation of a new Dept. of Metallurgical Engineering. Formerly, metallurgical activities were combined with those in mining and petroleum engineering in the Div. of Mineral Technology, School of Mineral Sciences. O. Cutler Shepard has been appointed executive head of this new department. However, since he is currently on leave, Professor A. Huggins is

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MBD Bylaws

(Continued from page 119)

Electrical Interlocks; Signalling Devices.

f. *Chemical Process:* Cyanidation; Leaching; Precipitation; Electrolysis; Crystallization; Hydrometallurgy.

g. *Pyrolysis and Agglomeration:* Roasting; Sintering; Nodulizing; Briquetting; Pelletizing; Distillation and Condensation.

h. *Mill Design:* Engineering; Construction; Organization; Start-up; Organizing Engineering Department; Handling Engineering with Contractors; Contracting for Construction; Analyzing and Estimating Installation Costs; Designing Flow Sheet; Basic Design Problems.

i. *Basic Science:* To foster the development of technologies pertinent to the interests of this Division, by sponsoring technical sessions and papers on research and theoretical subjects.

Section 3. The General Committee may establish additional Technical Committees, and may also eliminate existing Technical Committees.

Section 4. Nominating Committee (**Article VIII,** *Section 3*).

Section 5. The Membership Committee shall consist of a Chairman, four Vice Chairmen, and five or more other members.

It shall be the duty of this committee to encourage and solicit applications for membership in the AIME and in the Division in accordance with the Bylaws and Constitution of the AIME, and to cooperate with the Membership Committee of the Society and General Membership Committee of AIME.

The Chairman shall be nominated and elected in the same manner and at the same time as the other Division officers; he shall serve for a period of two years, and shall also serve as MBD representative on the Society Membership Committee.

The Committee Chairman shall appoint the Vice Chairman and Committeemen with advice and approval of the Chairman of the Division.

Section 6. The Program Committee shall consist of the MBD Associate Chairman, who shall head the Committee, and the Chairmen of all Division Committees responsible for technical papers

It shall be the duty of this committee to secure papers for presentation at the meetings, and to arrange the programs for the presentation of said papers at all meetings of the Minerals Beneficiation Division.

The Chairman of the MBD Program Committee shall serve as a member of the Society Program Committee.

Section 7. The Papers and Publications Committee shall consist of seven or more members including a Chairman.

The duties of this Committee shall be to examine and review all papers in its field submitted to the Society and the AIME for publication; to evaluate reader comment obtained on each paper; and to recommend to the Society Transactions Editorial Committee as to acceptance or rejection of papers as "Technical Publications" or "Contributions" or "Technical Notes." It shall be the responsibility of this Committee to determine the types of papers to be published by the Division and to maintain high standards as to quality; and to adjust its recommendations to the space allocated to the Division by the Society Transactions Editorial Committee.

The Chairman shall serve as MBD representative on the Society Transactions Editorial Committee.

The Chairman shall be nominated and elected in the same manner and at the same time as the other Division officers.

Section 8. The Education Committee shall consist of a Chairman and five to seven other members.

The Education Committee Chairman shall serve as an MBD representative on the Society Education Committee.

Two other Education Committee members, preferably one from industry and one from an educational institution, shall be appointed by the Division Chairman to serve on the Society Education Committee.

The Chairman shall be nominated and elected in the same manner and at the same time as the other Division officers. The Committee Chairman shall appoint the Committeemen with the advice and approval of the Chairman of the Division.

The duties of this Committee shall be to further education in minerals beneficiation, to study the needs of industry and recommend, by the medium of reports or papers, topics for curricula in minerals beneficiation. This Committee shall further take steps as it deems advisable and necessary to encourage operating companies to provide opportunity for summer employment for students in minerals beneficiation plants.

Section 9. The Technical Committees shall consist of a Chairman, Vice Chairman, and three to five additional members. Not more than two shall be from the same geographical area.

The duties of these Committees are to advise the Program Comittee in regard to interesting trends and developments, and to secure appropriate technical papers for programs and/or publication. These committees shall also assist Local Sections in securing papers for local and regional meetings when requested by Local Section Chairmen or Program Committees.

The Chairman shall be nominated and elected in the same manner and at the same time as the other Division officers. The Committee Chairman shall appoint the Vice Chairman and Committeemen with the advice and approval of the Chairman of the Division.

Article VIII

Nominations and Elections of Officers and Committees

Section 1. The officers of the Division shall be nominated and elected in the same manner as hereinafter provided.

Section 2. Each year the Division shall elect a Chairman, an Associate Chairman, a Secretary-Treasurer, two Regional Vice Chairmen, and the Chairmen of each Technical Committee and of each of the Standing Committees except the Nominating Committee.

The Division shall also elect each year such other representatives to the Society Committees as required, including the Admission Committee (two members), and the Mineral Economics Committee (one member).

Section 3. The Nominating Committee shall be composed of five immediate Past Chairmen and the incumbent Chairman and Associate Chairman of the Division. The oldest in line of service shall be Chairman of the Nominating Committee.

Section 4. The MBD Nominating Committee shall appoint representatives for the Society Nominating Committee.

Section 5. After the Nominating Committee has selected the slate of nominees, the Chairman of the Nominating Committee shall notify and obtain acceptance from each nominee. The Nominating Committee shall then make its report to the Executive Committee not later than June 1, so that the Chairman of the Division can report the Nominations to the Secretary of the Society.

Section 6. The list of the nominees for officers shall be published in MINING ENGINEERING, and the *MBD Newsletter*, as soon as possible after the Society Secretary has been advised. The names of the nominees thus published will be considered elected for the ensuing year except as provided for in *Section 7*.

Section 7. Any ten members of the Minerals Beneficiation Division may submit nominations for one or more officers to the General Committee of the Minerals Beneficiation Division, not later than August 15. In case of such additional nominations, then there shall be a letter ballot sent out to the members of the Minerals Beneficiation Division only, by September 1. Votes may be received by November 1, and shall be counted

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Meeting On Reactive Metals in Buffalo

The third annual Regional Reactive Metals Conference, AIME, is to be held in Buffalo's Hotel Statler on May 27 to 29, under the sponsorship of the Niagara Frontier Section.

Topics to be discussed are the production, properties, fabrication, and application of tantalum, columbium, titanium, zirconium, hafnium, vanadium, molybdenum, tungsten, thorium, uranium, and their alloys. The daytime technical sessions will be followed by outstanding evening events. For one evening, a panel discussion is scheduled on the future of the reactive metals. A fellowship hour, banquet, and nationally known speaker will make up the second evening's program.

An exhibition pertinent to the entire field of reactive metals will be on display at the Statler Hotel during the Conference.

Chairman of the meeting is S. F. Urban, Titanium Alloy Mfg. Div., National Lead Co. His committee consists of the following: *administration*, J. D. Roach, Titanium Alloy Mfg. Div., National Lead Co.; *arrangements*, E. L. Gielzen, Bethlehem Steel Co.; *exhibits*, R. K. Kulp, Electro Metallurgical Co.; *finance*, W. W. Stephens, Carborundum Metals Co.; *plant visitations*, C. Fogel, Universtiy of Buffalo; *program*, W. Clough, Electro Metallurgical Co.; *publicity*, C. W. F. Jacobs, Titanium Alloy Mfg. Div., National Lead Co.; and *registration*, C. H. Emery, Simonds Saw and Steel Co.

The first conference was held in Buffalo in March 1956, and the second meeting was a joint one with mining and metals groups in Los Angeles in May 1957.

Engineering Who's Who

A new edition of *Who's Who in Engineering* is now being prepared by the publishers, the Lewis Historical Publishing Co. Over 4000 AIME members have—or will—received requests for biographical data. Those biographies which meet the standards of professional eminence, years of active practice in their profession, and years in the technical teaching field will be included in the new volume.

EJC has a task committee to cooperate with the publishers in an effort to make the volume as complete as possible. AIME representative on this committee is Edward H. Robie.

The last edition of the work included 18,000 names, indicating that perhaps about one in ten members of the leading national engineering societies were eligible for listing. The publishers have emphasized that purchase or nonpurchase of the volume has no bearing on the inclusion of names.

National Science Foundation Awards

Senior postdoctoral fellowships will be awarded on Mar. 18, 1958, by the National Science Foundation. Approximately 25 senior postdoctoral fellowships will be awarded to persons planning additional study and/or research to 1) increase their competence in their specialized fields of science or 2) broaden their competence in related fields of science. For full information in regard to eligibility for and provisions of these fellowships write to: *Div. of Scientific Personnel and Education, National Science Foundation, Washington 25, D. C.* Application materials may also be obtained from this division and completed materials must be received by the division no later than Jan. 13, 1958.

To Report on Mineral Economics Volume

After the luncheon sponsored by the Council of Economics of AIME on Wednesday, February 19th during the Annual Meeting, a progress report on the mineral economics volume now in preparation will be presented. Another important item on the agenda is a discussion of the possible preparation of a volume on the management of mineral properties to follow as No. 2 of the series that starts with the mineral economic volume. All those interested in such a project are urged to attend and to offer their comments on the subject.

Roger Straus Memorial

As a memorial in honor of her late husband, Mrs. Roger W. Straus on Oct. 28, 1957, announced a gift of $1,000,000 to the Roger Williams Straus Memorial Foundation Inc. to promote the objectives of the National Conference of Christians and Jews Inc. and the World Brotherhood organization.

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International Mining Days Held in El Paso November 6 to 9, 1957

The 1957 International Mining Days and New Mexico Mining Assn. Convention were held in El Paso, Texas, November 6 to 9, with an attendance of close to 600.

Starting with registration on the 6th, the proceedings got really under way the next day with the welcoming luncheon at the Hotel Paso del Norte, headquarters for the meeting. Presiding was Edward W. McQuade, general chairman, and guest speaker was Major General W. E. Laidlaw, commanding general of the White Sands Proving Grounds.

Technical sessions were scheduled Thursday afternoon, Friday, and Saturday, with a wide range of subjects covered. Among these were Arizona mining, with emphasis on the regional structure of the southern parts of the state, and New Mexico mining, touching upon the growth of the state's mineral industry. Friday was New Mexico uranium day, with technical sessions devoted to geology, prospecting, mining, and milling.

In addition to the welcoming luncheon, a variety of social events were scheduled throughout the meeting. On Thursday evening, the AIME El Paso Section was host to the AIME banquet, with M. S. Bell, Section chairman, presiding. At the Friday International Mining Days general luncheon, the Hon. Edwin L. Mecham, Governor of New Mexico, was the principal speaker. J. K. Richardson, president of the New Mexico Mining Assn., was chairman. The luncheon was followed by the association's annual meeting.

A ranchero breakfast opened the Saturday events. Luncheons on that day were arranged by individual groups and the afternoon was free for sports or sightseeing. A suppliers' party, held Friday afternoon, preceded the homecoming game between the Miners of Texas Western and the Arizona State Sun Devils. For those not attending the football game, there was entertainment and dancing at the Coliseum.

During the three-day meeting, there were numerous activities for the ladies attending with their husbands. On Thursday and Friday, there was a morning coffee session, with the opportunity on the latter day to view a style show arranged by the Popular Dry Goods Co. On Thursday the American Furniture Co. arranged a special interior decorating lecture and tour. A luncheon and style show wound up the program on Saturday.

New officers of the New Mexico Mining Assn., named at the annual meeting, were Russel G. Haworth, Potash Co. of America, president; T. O. Evans, Atchison, Topeka, and Santa Fe Railroad, first vice president; and A. L. Greslin, Molybdenum Corp. of America, second vice president.

Committee chairmen for the International Mining Days were E. W. McQuade, executive committee; Homer C. Hirsch, entertainment; A. L. Washburn, ranchero breakfast; Gus Momsen, suppliers' party; Ben Roberts, technical porgrams; Mrs. C. S. Harper, Jr., women's; T. R. Lind, hotel and housing; R. J. Benson, registration; and Mallory Miller, invitation.

Stanford

(Continued from page 120)

acting executive head for the academic year 1957-1958.

During the last few years there has been a great increase in metallurgical activity at Stanford. A long-range program has been undertaken to interest high school students in this field, as well as to bring the opportunities in metallurgy to the attention of students currently enrolled in the university. As a result, there has been a very significant increase in the student body at both the undergraduate and graduate levels—the total enrollment having increased by a factor of five over the past five years.

In addition, an active graduate research program has been developed. Current research in the department includes work on diffusion kinetics in polyphase systems and systems in which a dispersed second phase is being formed. Programs are being undertaken to study the mechanisms by which dispersed phases affect creep behavior, and the effect of solute elements on the mechanical behavior of grain boundaries at elevated temperatures. A fundamental study of some of the factors that control the creep strength of brazed joints is also underway.

The curriculum has been extensively revised and enlarged. Its design is such that it is now possible for students to combine successfully their interests in metallurgy and any of several other fields. This is accomplished by requiring that all students take a common group of fundamental courses, and allowing them to supplement this core by one of several broad elective programs.

In order to accommodate these increased activities, considerable improvements have been made in the physical facilities of the Dept. of Metallurgical Engineering. Several valuable pieces of equipment have recently been acquired for use in teaching and research programs. These include a commercial vacuum melting and casting furnace, new X-ray diffraction spectrometer and fluorescence analysis equipment, and an additional induction heating unit.

Within the last few years over 2800 sq ft of laboratory space has been either newly constructed or completely renovated. These improvements raised the total laboratory space available to the department to over 13,000 sq ft not including classrooms and offices.

MBD Bylaws

(Continued from page 121)

by a Committee of Tellers appointed by the General Committee. Candidates receiving a majority of such votes shall be certified to the Society Secretary by the Chairman of the Division.

Section 8. If for any reason, an officer or member of the Executive Committee resigns or can no longer serve, the Nominating Committee of the Minerals Beneficiation Division shall select a successor.

Article IX

Newsletter

Section 1. The *MBD Newsletter* or MINING ENGINEERING shall be the Division's official medium for advice of meetings, nominations, amendments, etc.

Article X

Local Groups or Clubs

Section 1. Local Sections and Subsections are provided for in the Bylaws of the AIME.

Local groups in the various geographical sections of the AIME, or local clubs, may be formed by members of the Minerals Beneficiation Division, as provided in the Bylaws of the AIME.

Article XI

Amendments

Section 1. Proposals to amend these Bylaws shall be made in writing to the General Committee of the Minerals Beneficiation Division and signed by at least ten members; such proposals shall be considered by the General Committee and announced to the members of the Division through the columns of the *MBD Newsletter*, or MINING ENGINEERING, together with any comments or amendments made by the General Committee thereon. The General Committee shall provide proper facilities for a vote of the membership of the Division on such proposals within 60 days from the date they are submitted to the General Committee. If favored by a majority of the ballots cast, the amendments shall thereupon be submitted to the Board of Directors of the Society and the Board of Directors of the AIME for approval.

Around the Sections

• The **Boston Section** featured a double program at their second meeting on November 4, at the Massachusetts Institute of Technology Faculty Club, Cambridge, Mass. The bill began with *Mining for Nickel*, a 30-min color film produced by the International Nickel Co., covering the prospecting, the development, and mining of a nickel deposit. The second part of the meeting introduced Anthony Werner, geologist from England, who has engaged in helicopter prospecting at the Mesters Vig Mine, Greenland. Mr. Werner gave a talk emphasizing modern prospecting and presented a showing of his collection of color slides.

AIME President Grover J. Holt was guest of honor and speaker at the Section's December 2 meeting also held at the MIT Faculty Club in Cambridge.

• The **Washington, D. C., Section** met for cocktails and dinner on November 12 at the Cosmos Club, Washington. F. R. Morral, Cobalt Information Center, Battelle Memorial Institute, Columbus, Ohio, was the featured after-dinner speaker. He presented a 20-min talk on the metal cobalt, followed by a movie which depicted the production of cobalt in Katanga, Belgian Congo.

• A meeting of the **Oregon Section** was held at the Albany Hotel, Albany, Ore., on October 18. The program featured Alva H. Roberson, supervising extractive metallurgist at the U. S. Bureau of Mines Laboratories, who spoke on the *History of Scrap Iron*, a talk on antique guns. His discussion was illustrated with a display of antique firearms. The Section held a dinner-meeting on November 15, at Burns Restaurant, Portland. The principal speaker was L. W. Meyer, assistant works manager, fabricating division, Vancouver Plant, Aluminum Co. of America. His topic was, *A Gringo Looks at Changing Mexico*.

• The fall dinner meeting of the **Lehigh Valley Section** was held on October 25, after cocktails, at the Hotel Traylor, Allentown, Pa. The guest speaker was John F. West, assistant atomic power engineer of the Pennsylvania Power & Light Co. Mr. West showed detailed slides which pictured the progress being made with an aqueous homogeneous reactor now being built at Pittsburgh by Westinghouse Electric Corp. and the PP&L. He said that, if the reactor is successful, a few ounces of thorium mixed with uranium and heavy water would do the job of 750 tons of coal.

• The **El Paso Section** banquet for International Mining Days was held on November 7, at the Terrace Ball Room, Hotel Cortez, El Paso. The speaker of the evening was John K. Minnoch, internationally known lecturer, who spoke on *Business is Business* or *Laugh and Live*.

• The **Ajo Subsection** met on November 14 at the Copper Coffee Shop, Ajo, Ariz. The featured speaker, J. A. McAllister, field representative for the American Cyanamid Co., gave a talk on South Africa and his experiences there. He covered the history, constitution and political phases, and various mining operations of the country. Mr. McAllister highlighted his discussion with some color slides of the country and his trip.

• A panel discussion keynoted the November 21 meeting of the **Utah Section** held at the Newhouse Hotel, Salt Lake City. With Norman L. Weiss as moderator, four speakers from fields related to the mining industry probed the subject: *Mining Industry: New Methods, Machines, and Materials*. The panel speakers were Harvey Mathews, vice president, Stearns-Roger Mfg. Co., civil engineer; James D. Moore, chief process engineer, Vitro Uranium Co., chemical engineer; P. K. Richardson, power engineer, American Smelting & Refining Co., electrical engineer; and Joseph Rosenblatt, president, Eimco Corp., mechanical engineer.

• Winnemucca, Nev., was the site of the **Reno Subsection** meeting held in October. Seventy-nine mining experts and students from northern Nevada and Oregon attended the conference which aimed at more active participation of members in isolated mining communities in the northern part of the state. Early in the day, students were given tours of the Dodge Construction Co. and Minerals Material Co. iron ore mining operations south of Lovelock, Nev. The students were accompanied by Lawrence Beal of the Nevada Bureau of Mines in Reno, and Professor John N. Butler of the Mackay School of Mines, University of Nevada. Mr. Lawrence said that a possible return visit to Winnemucca next fall was planned, among other similar programs. Speakers for the conference included Enoch Brown, Magnet Cove Barium Corp., Battle Mountain, on barium; William P. Johnston, Reno geologist, on Nevada's iron mining; Edwin Fisk, Cordero Mine, on quicksilver and mercury; and Roy Hickman, Arentz-Comstock Mining Co., on mercury operations.

A luncheon meeting of the Subsection was held on November 8, in the Nevada Room of the Mapes Hotel, Reno. The program featured Bill Freeman and Dave McCrillis, students at the Mackay School of Mines, University of Nevada, who spoke on their experiences during last summer's employment by the Cerro de Pasco Mining Co. in Peru.

• The **Uranium Section** met for dinner on November 5 at the National Lead Co. Guest House, Monticello, Utah. After dinner and a brief business meeting, an introductory talk was given by C. H. Reynolds, general superintendent, Continental Materials Co. A film, *The Rattlesnake Operation*, was presented, followed by a geological description of the Rattlesnake ore body by John G. Roscoe. A colored slide presentation and detailed description of the Rattlesnake mining operation by Maurice H. Brady then ensued, concluding with a lengthy discussion period of the material covered.

On December 6, a dinner-dance was sponsored jointly with the Section's Women's Auxiliary, at the Towne and Country Club, Moab, Utah.

• Stanford University students were the hosts of the **San Francisco Section's** annual joint dinner meeting, held on November 13, at Stanford Union on the Stanford campus with the Student Chapters of Stanford University and the University of California. A duel program was featured in which the students reviewed the activities and programs of the geology, petroleum, and physical metallurgy departments followed by a showing of the color film *Mining and Milling at International Nickel*.

• The **Upper Mississippi Valley Section** met on October 14 at the Wisconsin Institute of Technology. The featured speaker was George Wollard, internationally known geophysicist and professor of geophysics at the University of Wisconsin, who spoke on the International Geophysical Year. Dr. Woolard stated that some phases of the 18 separate scientific areas being investigated will not be completed for approximately five years. Among those areas of study listed are earth structure, magnetism, oceanography, meteorology, cosmic rays, and astronomy. He also praised the cooperation to date of all participating scientists and the numerous instances in which political barriers have been lowered in the interest of science. Preceding Dr. Woolard's talk, new Section officers were elected for 1958. They are: Wayne Zwickey, chairman; Robert Haffner, vice chairman; and Tom Mullens, secretary-treasurer.

• E. C. Stephens, head of the Anaconda Co.'s Northwest exploration office, Spokane, was elected chairman

(Continued on page 125)

PERSONALS

A. J. Presanis is now working with the Mykobar Mining Co., in Mykomos, Greece.

Herbert Wells, formerly operational engineer for the Climax Molybdenum Co., Climax, Colo., is now associated with the Titanium Metals Corp. of America, Las Vegas, Nev., as a process engineer.

Stanley Rothschild is now mineral dressing engineer in the development section at the Pine River Plant of the American Cyanamid Co., pigments division, Nelson County, Va. He was previously a research fellow in the department of mineral preparation, College of Mineral Industries, Pennsylvania State University, University Park, Pa.

Bruce Condie, previously with the Ely Valley Mines Inc. as superintendent, has now joined the Federal Uranium Corp. in Utah as assistant superintendent.

Wallace R. Oref is now vice president of Penn-Idaho Mines Inc. in Idaho. He formerly was a field geologist for the Equitable Gas Co., Pittsburgh.

Henry E. Mensing has been transferred by National Gypsum Co. from Bellefonte, Pa., where he was mine foreman, to York, Pa., where he is mill foreman.

C. E. Osborn, who was general superintendent, Navajo Uranium Div.,

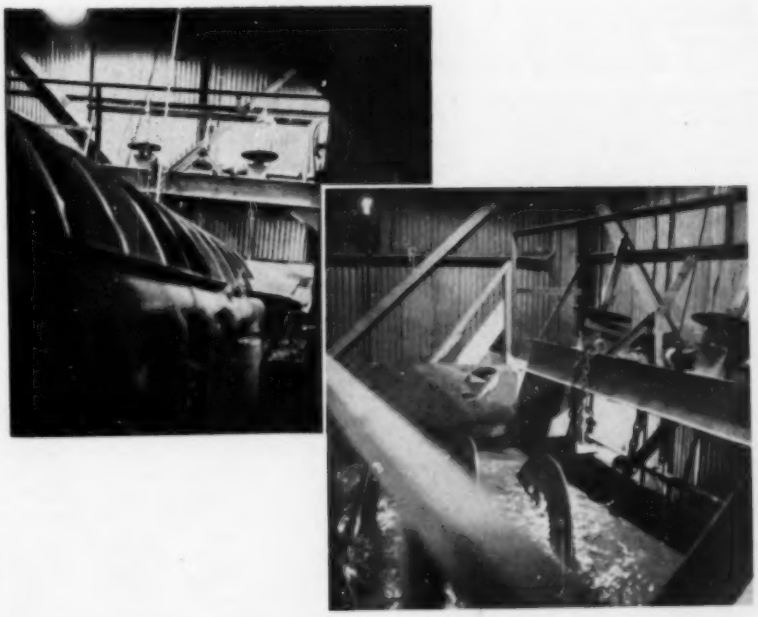
(Continued on page 127)

Around the Sections

(Continued from page 124)

of the **Spokane Subsection** and vice chairman of the **Columbia Section.** He is filling the unexpired term of Lowell B. Moon, who is now development manager for Kennecott Copper Corp., New York. Because of the anticipated departure of Robert J. Hundausen, John W. Cole has been appointed secretary, and Carlos E. Milner Jr., has been appointed program committee chairman.

• A dinner meeting of the **Pittsburgh Section** was held on November 20 at the Club Room Park Schenley Restaurant, Pittsburgh. The guest speaker was Elmer W. Pehrson, chief, division of foreign activities, U. S. Bureau of Mines, Washington, D. C., who discussed *Asia and Its Mineral Industries.* His talk, illustrated with kodachrome slides, was based on an extensive trip he made recently to the East and the Middle East, visiting 26 countries. Mr. Pehrson's presentation dealt with the Jewish and Arabian situation, oil, and the many other problems in this tense and important part of the world.



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Books

(Continued from page 6)

Beckman/Process Instruments Div., Fullerton, Calif, 2.00, 80 pp., 1957.—The handbook is the first manual published giving thorough coverage of industrial pH information. Reviewed are: industrial pH control systems, their principles, and application engineering and equipment, providing a convenient reference source on pH for persons involved in designing, engineering, purchasing and operating industrial pH systems. Nearly 100 illustrations, plus charts, tables, and a bibliography of reference literature on pH measurement are contained in the manual.

Occurrence of Oil and Gas in Texas, Vol. 2, The University of Texas Publication 5716, Bureau of Economic Geology, *The University of Texas*, University Station, Austin, Texas, $10.00, 456 pp., 1957.—The book is the result of a cooperative effort between the West Texas Geological Soc. and the Bureau of Economic Geology. Described in this publication are 112 fields. Most of the field papers include structure maps and graphic typical section of rocks penetrated, with electric log. Some cross sections of the fields are shown. The data also includes location, history, details of occurrence of oil and gas in the reservoir rocks, stratigraphic and lithologic details of the rocks, nature of trap, productive area, information on character of oil and gas recovered, and production history.

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A Geological Map of the Bend Quadrangle, Oregon, and a Reconnaissance Geological Map of the Central Portion Of The High Cascade Mountains by Howel Williams, *State of Oregon Dept. of Geology and Mineral Industries*, 1069 State Office Bldg., Portland, Ore., in cooperation with the United States Geological Survey. The full color maps along with the reports contained cover glaciated lavas of the High Cascade volcanoes, intracanyon basalts, recent pumice avalanche deposits, structure, youngest basalts, recent dacites, etc. A selected bibliography is included with the report.

The Federal Lands: Their Use and Management, by Marion Clawson and Burnell Held, *The John Hopkins Press* (for Researches for the Future Inc.), Baltimore, 18, Md., $8.50, 536 pp., 1957.—The authors examine the management of the federal lands from an economic viewpoint. They analyze the most important changes, which they believe are seriously out of date, resulting from the shift from custodial management to the present-day form of intense management. How these changes came about, what they mean for the future, and some of the alternatives for dealing with them are also discussed by the writers. •

Field Guidebook No. 9—Rocks associated with the Mississippian-Pennsylvanian unconformity in southwestern Indiana, *Geological Survey, Indiana Dept. of Conservation*, Publications Section, Indiana University, Bloomington, Ind., $1.00, 42 pp., 1957.—The guidebook, prepared for a field conference held October 1957, contains an introduction to the physiography, Paleozoic stratigraphy, geomorphic history, and economic geology of parts of Lawrence, Martin, Orange, and Crawford Counties. Ten stops in this area are described in the itinerary. Illustrations include a map showing the route of the conference, a generalized columnar section representing the rocks of the area, and a chart summarizing the evolution of stratigraphic nomenclature of the Chester series in Indiana.

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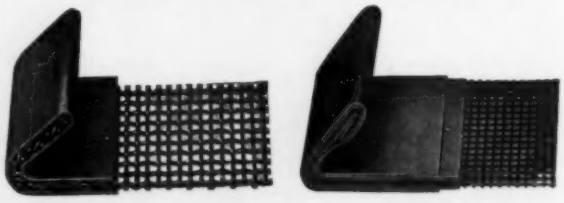

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Personals

(Continued from page 125)

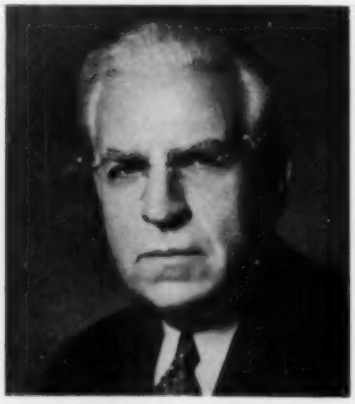
Kerr-McGee Oil Industries Inc., is now chief metallurgist for Homestake-New Mexico Partners, Grants, N. M. Prior to becoming chief metallurgist, Mr. Osborn had served as consulting metallurgist for Rio de Oro Uranium Mines Inc. and United Western Minerals Co., the two companies that formed a limited partnership with Homestake. As chief metallurgist, Mr. Osborn is taking an active part in the planning and erection of a 750-tpd uranium oxide concentrator near Grants. He is also one of the limited partners of the concern.

Richard E. Dante, who graduated in June from the University of California with a degree in mining engineering, is now associated with the International Nickel Co. of Canada Ltd. in Thompson, Manitoba, Canada.

R. C. Bacon, formerly vice president of Ventures Ltd., has joined the staff of C. F. Braun & Co., engineers, Alhambra, Calif. He is located in the company's New York office.

Don L. Cenis, who had been a research fellow at Montana School of Mines, is now a mining engineer for Western Nuclear Corp., Rawlins, Wyo. He had worked at one time on the USBM-sponsored program of research into hydraulic back-filling of metal mines.

George F. Leaming is now design engineer for San Manuel Copper Corp., San Manuel, Ariz.



L. C. CAMPBELL

Luther C. Campbell, vice president of Eastern Gas & Fuel Assoc., Pittsburgh, retired on Nov. 30, 1957. He has been a mining engineer for 42 years, 30 of them with Eastern's coal division and its predecessors. A native of Renova, Pa., Mr. Campbell was graduated from Pennsylvania State University in 1915 with a degree in mining engineering. He began his employment with Eastern and its predecessor organizations in 1927 when he became general superintendent for the Melcroft Coal Co. and later for the Elkhorn Piney Coal Mining Co., both of which later became part of the Koppers Coal Co., now the Coal Div. of Eastern Gas & Fuel Assoc. He was elected vice president of Eastern in 1943. Throughout his career, Mr. Campbell has been active in the mine safety and welfare movement of his organization, in the National Safety Council, the U. S. Bureau of Mines, and other organizations which promote human welfare. Among other numerous activities, Mr. Campbell has served four terms as president of the National Coal Assoc. (1952-1956) and is now an NCA director and member of its executive and finance committees. He was a chairman of the coal division of the American Mining Congress. In 1956 he was elected a director of AIME and was awarded the Erskine Ramsay Gold Medal by the Institute in recognition of his preeminence in coal mining engineering. In addition Mr. Campbell is a director of Bituminous Coal Research Inc. He has stated that his future plans include remaining active in coal mining as a consultant at headquarters which he will open in Pittsburgh.

L. A. ROE

Lawrence A. Roe, formerly manager of process engineering for International Minerals & Chemical Corp., Chicago, has been promoted to director of central engineering and will direct the company's programs in construction, process, and general engineering.

Wilbur D. Lawson, formerly fuel engineer for Pittsburgh Consolidation Coal Co. in the New York and Baltimore areas, was recently appointed field service engineer for Bituminous Coal Research Inc., Columbus, Ohio.

Roy E. Mallory, previously plant engineer with National Lead Co., Monticello, Utah, is now working as resident engineer for F. C. Torkelson Engineers of Salt Lake City. He is presently engaged on the construction of the Central Farmers Fertilizer Co. phosphorous concentrating plant at Georgetown, Idaho.

M. GUERRA

Mario Guerra is now working as mine foreman for the Cerro de Pasco Corp., Yauricocha, Peru. He formerly served as mining engineer with the Empresa Minera de Nicaragua, Managua, Nicaragua.

Stan Beitscher has been transferred from the General Electric Co.'s Cleveland Wire Plant where he was an engineer trainee, to the company's Philadelphia Switchgear Plant where he is serving in the same capacity.

Jack D. Halen is now associated with the U. S. Steel Corp., Pittsburgh. He formerly was vice president in charge of mining for Warren Foundry & Pipe Corp. (now Shahmoon Industries) in Dover, N. J.

David F. Shaw has been appointed vice president of Kaiser Engineers, division of Henry J. Kaiser Co., Oakland, Calif.

L. W. COPE

Louis W. Cope is general superintendent for Compania Minera Los Angeles S.A., with mine and plant located at Valle de Angeles, Honduras. He had been associated with Buchans Mining Co. Ltd., Buchans, Nfld., Canada.

Seaboard Oil & Gas Co. of Wichita Falls, Texas, acquired assets and liabilities of Capitol Uranium Co. and changed its name to Capitol-Seaboard Corp. **Fred Carson,** Capitol chairman, **Charles W. Yetter,** president of the uranium company, and **William A. Pope, Jr.,** secretary-treasurer, became directors of Capitol-Seaboard. Mr. Yetter is executive vice president of the corporation and also president and general manager of Engineer Assoc. Inc., a consulting engineering firm in Grand Junction, Colo.

Fritz Mohr delivered four lectures recently at the Pennsylvania State University as visiting professor of mining engineering. The lectures, illustrated with slides and movies, described his work in the field of rock mechanics. Dr. Mohr is president of a shaft sinking company in Essen, Germany, and honorary professor of mining at Clausthal Bergakademie.

Correction

Howard L. Hartman was incorrectly listed on p. 1282, November issue, as head of the mining department at Colorado School of Mines. Dr. Hartman, a graduate of The Pennsylvania State University, has become professor and head of the Dept. of Mining at Penn State. He replaces **Arnold W. Asman,** formerly at Penn State. Dr. Hartman, author of a number of papers on mine ventilation and dust control and rock penetration, holds a Ph.D. in mining engineering from the University of Minnesota. In addition to teaching at Colorado School of Mines, Dr. Hartman also served as a consultant to the Indian Claims Section, U. S. Dept. of Justice, on mineral valuation of lands belonging to the Utes. He was also consultant to the Colorado Highway Dept., as well as to several mining companies at various times during his residence in Colorado.

C. W. YETTER

The following staff changes have taken place in the Dept. of Geology and Geophysics at Massachusetts Institute of Technology, Cambridge, Mass: **Walter L. Whitehead** retired in June but continued as director of the MIT summer school of geology at Crystal Cliffs, N. S., Canada, is serving as lecturer in geology for the 1957-1958 term, and is visiting professor at St. Francis Xavier University, Antigonish, N. S., Canada. **William S. von Arx** and **J. Brackett Hersey** have been appointed associate professors and are giving a lecture course in physical oceanography and supervising graduate thesis work of MIT students at Woods Hole, Mass. **Arthur J. Boucot** has joined the staff as assistant professor of geology, working in paleontology and sedimentology. He will direct the MIT summer school of geology. **Harry Hughes,** scientific officer, United Kingdom Atomic Energy Authority, is visiting lecturer in geophysics while **Stephen M. Simpson, Jr.,** assistant professor in geophysics, is on leave. **James C. Savage** has been appointed lecturer in geophysics, **Theodore R. Madden** continues as lecturer, and **Norman H. Haskell** as research associate. In the Dept. of Meteorology, **Norman A. Phillips** has been appointed associate professor and **Lewis D. Kaplan** has also joined the staff after a year at Imperial College, London.

Allan R. Fraser has been named supervisor of extractive metallurgy and mineral dressing at Armour Research Foundation of Illinois Institute of Technology, Chicago. He will direct research associated with the economic recovery of metals or their compounds from ores, concentrates, slags, or scrap. Mr. Fraser was previously employed by Exothermic Alloys Sales & Service as technical director and Chromium Mining & Smelting Ltd. as director of research.

W. R. COOK

William R. Cook has been named to the post of wire mill superintendent of the Buffalo Plant of the Wickwire Spencer Steel Div., The Colorado

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Fuel & Iron Corp. Before joining CF&I, he had been associated with Union Wire Rope Corp, Kansas City, as assistant wire mill superintendent.

Roy T. McIntosh, service engineer for Boeing Airplane Co., Wichita, Kan., recently returned to the company's home office at Wichita, upon completing a year of duty at the Strategic Air Command station in Rosewell, N. M. Mr. McIntosh was the recipient of a letter of appreciation from the SAC wing commander, Col. C. F. Macomber, commending him on his outstanding performance of duty while assigned to the Wing.

R. T. McINTOSH

Charles E. Chapin was recently discharged from the service and has returned to work with the J. M. Huber Corp., St. Albans, W. Va., as a geologist in their timber and minerals division.

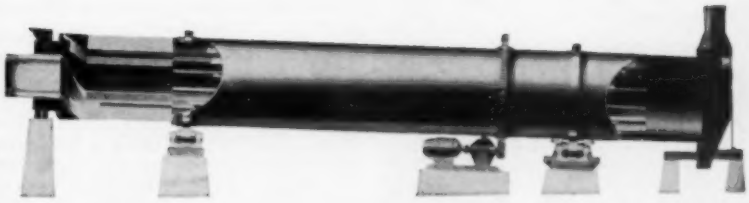
Myles A. Walsh, formerly senior engineer with the J. G. White Engineering Corp. in Formosa, is now employed by Ford, Bacon & Davis Inc. in Bolivia as a senior mining engineer. He is presently examining the tin mines of the Corp. Minera de Bolivia.

Guy Waddington was recently appointed director of the Office of Critical Tables in the division of chemistry and chemical technology of the National Research Council, Washington, D. C. Dr. Waddington previously served as chief of the Branch of Thermodynamics, U. S. Bureau of Mines, Petroleum Experiment Station, Bartlesville, Okla.

OBITUARIES

Paul D. Merica (Member 1918), an Honorary Member and former Vice President and Director of AIME, died on Oct. 20, 1957, in Tarrytown, N. Y. He had retired as president of the International Nickel Co. of Canada Ltd. in April 1954 but had continued to serve the company on im-

(Continued on page 130)



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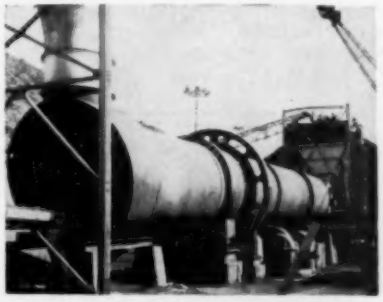
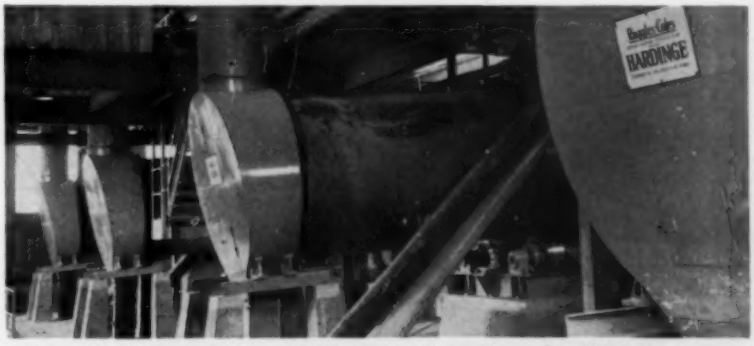


10' diameter, 80' long "XH" Ruggles-Coles Dryer drying bauxite in Jamaica.



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Obituaries

(Continued from page 129)

portant projects and as consultant to the officers. Born in Warsaw, Ind., in 1889, he attended De Pauw University, the University of Wisconsin, and the University of Berlin. Mr. Merica had been associated with the metallurgical division of the U. S. Bureau of Standards before beginning his long career with Inco in 1919. He served in a succession of positions before becoming president of the Canadian firm in 1952. His many contributions in the field of metallurgy brought him honors during his career among them the AIME James Douglas Medal, the John Fritz Medal, the Institute of Metals Medal, the Franklin Institute Medal, and the ASM Gold Medal. Mr. Merica was the recipient of honorary degrees from De Pauw University, Lehigh University, and Stevens Institute of Technology.

John W. Thompson (Member 1942) died in Salt Lake City, Sept. 22, 1957. The 82-year-old widely known developer of modern ore milling processes was born on Aug. 20, 1875, in Quincy, Calif., and graduated from the University of Nevada School of Mines in 1898. His career included employment as manager of the Checkmate Gold-Silver Mine at Pearl, Idaho; assistant superintendent of the Kearns-Keith property at Park City from 1906 to 1913; mechanical engineer for Mine & Smelting Supply Co. until 1914; and service to mining firms in Canada, Mexico, and Europe as well as the U. S. in the development of milling processes. Mr. Thompson later joined Galigher Co., as vice president in charge of field operations and held that post until his retirement several years ago.

• • •

An Appreciation By
A. C. Ensign

John W. (Jack) Thompson (Member 1942) age 82 years, vice president of the Galigher Co. in charge of field operations, and consulting engineer, died in a Salt Lake City hospital Sept. 22, 1957, of a heart ailment. It was with profound sorrow and a sense of great loss—throughout the mining industry—that Jack's countless friends and associates who loved him and honored him for his integrity, understanding, abilities, and warm Christian spirit learned of his passing.

He was respected greatly as a pioneer milling expert and his many valuable contributions to the perfection of milling methods and practices are of enduring value. Old in years, he was energetic, active, and an inspiration to all who were associated with him.

Early in his career, the flotation process came into prominence in the separation of different materials. Jack was quick to note that a machine capable of operation under all conditions was required. He and his associate, Lionel E. Booth, developed, and were granted a patent on, the Booth-Thompson machine used successfully for a number of years. It became known afterward as the AGITAIR machine and is being used in all sections of the mining world today.

His friends were legion, including leaders of industry on down through the spectrums of life to the man with the pick and shovel. He was known widely as a friend and leader, a worldwide contributor to the science of metallurgy, and a wise councilor capable and willing to share his knowledge. Perhaps his outstanding trait was his ability to instill confidence and learning in young engineers—many of whom he trained for service wherever ores were mined and metals were recovered.

His career took him to Spain, Mexico, Alaska, Canada, and all the mining communities in the United States. He was consultant for the Hudson Bay Mining & Smelting Co. in Canada and the Magma Copper Co. in Arizona at the time of his death.

From 1949 to 1954, he was in charge of perfecting a process suitable for extracting uranium and vanadium from the ore in the Colorado Plateau at Monticello, Utah.

Memorial Resolution

PAUL DYER MERICA

WHEREAS, with the passing of Dr. Paul Dyer Merica on the 20th October, 1957, in Tarrytown, N. Y., the Institute has lost one of its most loyal and distinguished members, and

WHEREAS, during his nearly 40 years of membership he served the Institute in a variety of capacities, including 12 years as Vice-President, and in 1942 was awarded Honorary Membership in the Institute, and

WHEREAS, during his professional life he made great contributions to the art of metallurgy, including his theory of the precipitation hardening of metals and alloys for which contribution he received the James Douglas Medal in 1929, the John Fritz Medal in 1938, the Institute of Metals Medal (Great Britain) in 1941, the Franklin Institute Medal in 1942 and the American Society for Metals Gold Medal in 1951, and Honorary Degrees of Doctor of Science from the DePauw University, Lehigh University and Stevens Institute of Technology,

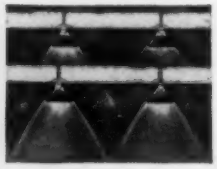
WHEREAS, both in his profession and in his association with the International Nickel Company of Canada Limited, of which he was President at the time of his retirement, he contributed throughout his life to the maintaining of the highest professional standards coupled with a personal character of the highest rank and a humanity which endeared him to all of his associates,

THEREFORE, BE IT RESOLVED, the American Institute of Mining, Metallurgical, and Petroleum Engineers records with deep sorrow the loss of this valued Member and friend; and

BE IT FURTHER RESOLVED, that this Resolution be spread upon the Minutes of this meeting and a copy be sent to Dr. Merica's mother.

Ernest Kirkendall
Secretary AIME

November 18, 1957



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Jack had enjoyed semi-retirement since Jan. 1, 1957.

He married Mary Hurley in Park City, Utah, in 1901. Mrs. Thompson died June 11, 1949. Alice Marie, a daughter, and Robert B. Thompson, a son, both of Salt Lake City, and five grandchildren survive him. Mr. Thompson was a member of the Catholic Church, Cathedral of the Madelaine Parish. Interment was in the Mt. Calvary Cemetery, Salt Lake City.

Fred Vincent Richard

An Appreciation By

Darwin J. Pope

On Sept. 5, 1957, Fred Vincent Richard (Member 1949) died suddenly of a coronary occlusion. He was only 45 years old and thus his career was only in mid-term. *Bud* Richard will be missed sorely by his many friends in all walks of life. He was always kindly and friendly to deal with, and in all the years I knew him, his temper was never ruffled.

Bud followed his father's footsteps in the mining business in which he was raised. After living in many mining localities, he grew up at the second Ground Hog Mine which his father had developed with a group of friends. *Bud* began his practical mine education in the Ground Hog, and after graduating as a mining engineer from the University of California, came back there to work, eventually becoming property superintendent for the American Smelting & Refining Co., which purchased an interest in the property and became its manager.

Richard spent most of his mining career with the American Smelting & Refining Co., being in its service 24 years. I knew him personally and intimately during the last half of this period and took many trips with him.

Bud is survived by his wife and three children, Ann, Fred and Linda.

Thomas Robins (Member 1892), 89, founder and former chairman of Hewitt-Robins Inc. and inventor of the heavy-duty belt conveyor now used extensively to transport coal, ore, and other bulk materials, died Nov. 4, 1957, in a hospital after an illness of several months. Born Sept. 1, 1868 in Highland Falls, N. Y., he attended Princeton University. Mr. Robins conceived the idea for the modern belt conveyor in 1891 and made his first sale to Thomas Edison's iron ore mine in Northern New Jersey. In 1896 he founded the Robins Conveying Belt Co. which was later merged with the Hewitt-Rubber Co. in 1945 to form Hewitt-Robins Inc. Mr. Robins served in the Naval Reserve from 1891 to 1898 and during President Wilson's administration was secretary of the Naval Consulting Board. He also served for a time as head of the Government's Board

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of Inventions. At the time of his death he was a member of the Century Assoc. and a member and former president of the Edison Pioneers, an organization formed several years ago to honor Edison. Mr. Robins wife, the former Winifred Howard Tucker, died in 1952. He is survived by two sons, Thomas Robins, Jr., chairman and president of Hewitt-Robins Inc., and Samuel Davis Robins, an inventor; seven grandchildren; and 12 great-grandchildren.

Theodore W. Becker (Member 1957) was killed in a helicopter crash at Rawlins, Wyo., on Aug. 16, 1957. Born June 29, 1920, in Akron, Ohio, he served in the Air Corps during World War II in the European Theater of Operations, leaving the service as a first lieutenant in 1945. In March 1949, Mr. Becker received his mining engineering degree from Michigan College of Mining and Technology, Houghton, Mich., and in June 1949, his degree of geological engineer from the same school. After graduation, he worked as a miner for Combined Metals Reduction Co., at Pioche, Nev. From 1949 to 1955, Mr. Becker was employed by the American Zinc, Lead, and Smelting Co. at Metaline Falls, Wash., where he rose to chief mining engineer, production department. He next served as a geologist for Loma Uranium Corp., Denver. At the time of his accident Mr. Becker was employed as a geologist for the Mining Div. of Union Pacific Railroad.

Harold J. Rahilly (Member 1916) died of a heart attack at his home in Whitter, Calif., July 25, 1957. Born at Lake City, Minn., in 1889, he graduated the School of Mines, University of Minnesota in 1911, and began his mining career in that state. Mr. Rahilly later worked in Mexico, Alaska, and Arizona, joining the U. S. Bureau of Mines at Pittsburgh in 1915. In 1917, he was employed by the Anaconda Co. and rose to become manager of mines at Butte, Mont., in 1947. He retired in 1951 and continued practice in Whitter as a consultant until his death.

Necrology

Date Elected	Name	Date of Death
1936	George O. Argall	Oct. 17, 1957
1917	John W. Austin	Nov. 22, 1957
1941	Perry L. Charles	Oct. 19, 1957
1954	D. E. Coughlin	Oct. 25, 1957
1909	Erle V. Daveler Honorary Member	Nov. 11, 1957
1910	Carl F. Dietz	Oct. 4, 1957
1904	F. W. Guernsey Legion of Honor	Nov. 1, 1957
1901	L. F. S. Holland Legion of Honor	Nov. 13, 1957
1949	Andrew Lesko, III	Oct. 19, 1957
1918	Carlton G. Lutts	Unknown
1914	Frederick MacCoy	Oct. 14, 1957
1892	Thomas Robins Legion of Honor	Nov. 4, 1957
1903	LeRoy Salsich Legion of Honor	Oct. 26, 1957
1891	Charles Henry Snow Legion of Honor	Oct. 28, 1957
1935	J. W. Stewart	Unknown
1956	Martin S. Taylor	Sept. 8, 1957
1952	W. C. Thompson	Oct. 22, 1957

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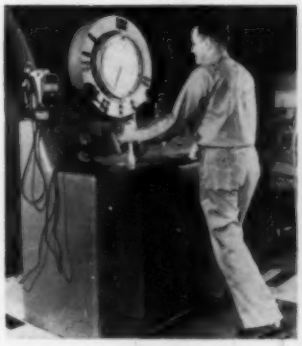

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